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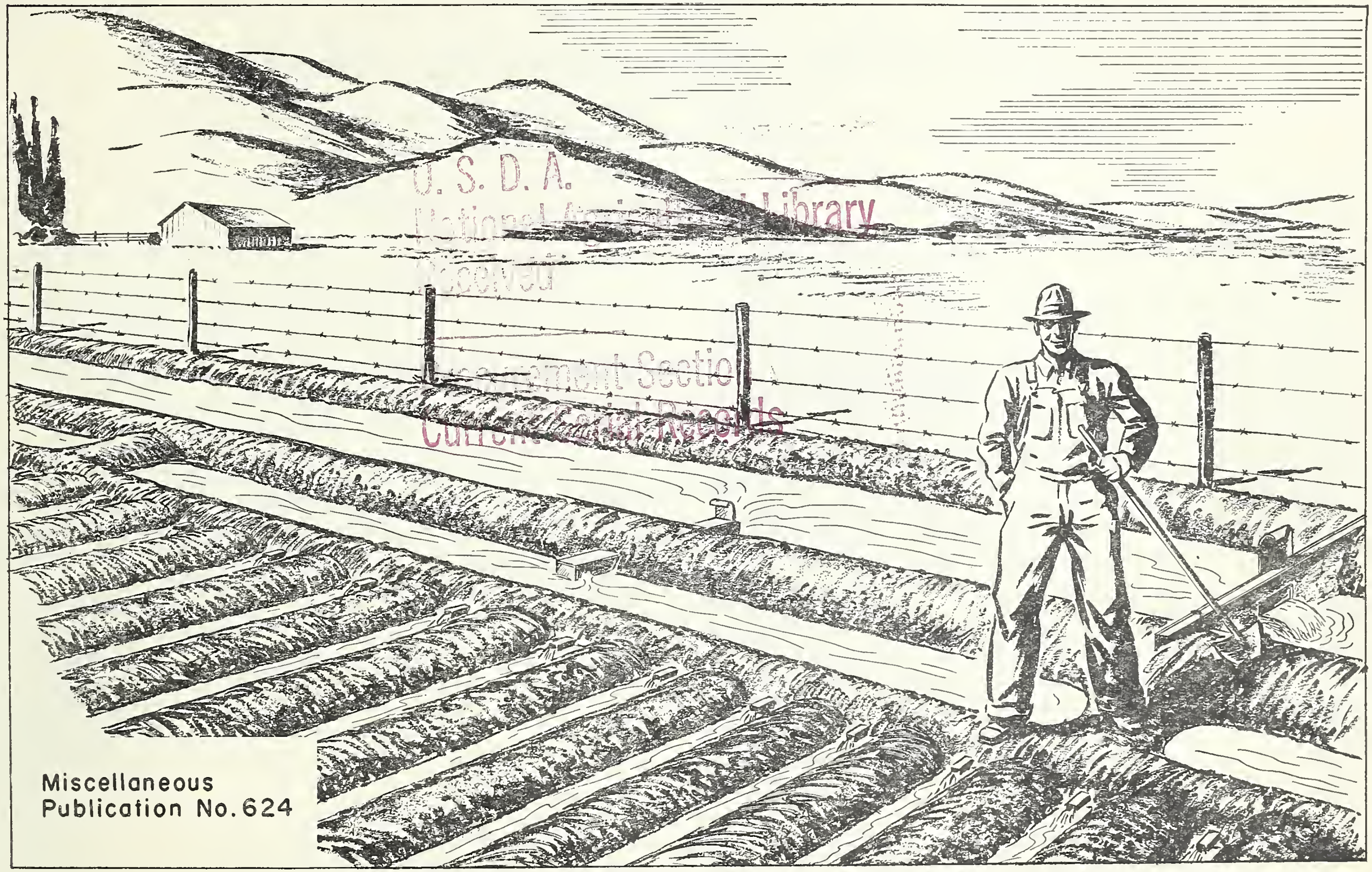
FIRST AID FOR THE IRRIGATOR



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FARMERS HOME ADMINISTRATION

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WASHINGTON, D. C., JUNE 1947

FIRST AID FOR THE IRRIGATOR

By Engineering Division
Farmers Home Administration[1]

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[1] Valuable contributions to this publication have been made by many persons. The following members and former members of the Engineering Division of the Farmers Home Administration have cooperated in the preparation of the material in this publication: Ivan D Wood, irrigation engineer; J. R. Stoker, civil engineer; H. F. McColly, civil engineer; R. O. Pierce, civil engineer. Illustrations are by Howard A. Moore, architect.

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IRRIGATION IN THE UNITED STATES

Long before the dawn of present-day history, ancient tribes of the American Southwest built large canals and laterals to irrigate thousands of acres of land. The area was divided into family or tribal farms in a manner closely resembling our modern methods of subdivision. Studies of these regions seem to indicate that those ancient fields were carefully leveled and watered with effective results.

In more modern times, our first irrigation systems were very simple. Early settlers diverted the waters of a stream to a hay meadow or down rows of corn or garden vegetables. Only the most favorably located lands were irrigated, and seldom were more than one or two farms served from a single canal.

As time went on, larger systems were constructed which could serve several hundred farms. The best engineering talent in the country was employed to design great dams, spillways, canals, and related structures. The science of water storage and transportation to the land developed rapidly. Little thought was given, however, to clearing of the native growth, leveling the land surface, plotting fields, and laying out farm distribution and drainage systems, all of which are important parts of the expensive and technical job of getting raw land into crop production.

The farmers themselves have developed by trial and error many good systems of water distribution and many good types of simple structures and equipment, some of which are described in this publication. In many sections of the West, however, primitive, laborious, and wasteful methods of water application are still in use.

Complete land development for irrigation means not only clearing and leveling, but also the construction and installation of control structures and the excavation of irrigation and drainage ditches. Modern methods of land development involve careful planning, designing and supervision by trained technicians, as well as the use of heavy-duty earth-moving equipment. The use of such equipment does away with the high costs per acre and long periods of lost crop production which the farmer usually encounters when he trys land development on a large scale, using small-capacity implements.

DEVELOPMENT OF LAND FOR IRRIGATION

The ground surface as prepared by Mother Nature is seldom suited to efficient application by gravity methods. The extent to which the ground surface may be leveled for irrigation depends on the cost of leveling and the depth of the soil. Heavy leveling requiring cuts of a few feet may be justified when the soil is deep, where the price of water is high, where high value crops are grown and the leveling can be done by heavy duty equipment to keep down the per acre cost of leveling. Some soils are so shallow and the subsoil so infertile that little, if any, leveling can be done profitably. Some leveling usually is necessary in all irrigation farming.

AIDS TO IRRIGATION

In irrigation farming the first problem to consider is that of bringing water to the land, and then getting the land ready for irrigation. This publication, however, is for the farmer to use when he already has his supply of water and the work of land development has been accomplished. It is a booklet of simple drawings and description of practical methods and easily made tools, equipment, and structures to use in the actual work of irrigating crops.

Most of the irrigation practices and the designs for equipment and structures shown in this booklet are not new. Through years of experience farmers have developed many good types of simple equipment and structures to help them irrigate their land. Some of these are described here. In some cases the good points of several designs have been put together and a new one developed. The various designs and methods shown are the result of the combined experience of practical irrigators, irrigation engineers, and others who have studied the art of applying water to the land.

The drawings and descriptions in this publication fall into three groups: water application, structures, and equipment. Some United

States Department of Agriculture publications which also may prove helpful to the irrigation farmer are listed below:

The Drainage of Irrigated Farms	Farmers' Bulletin No. 805
Irrigation Practices in Growing Alfalfa	Farmers' Bulletin No. 1630
Supplemental Irrigation	Farmers' Bulletin No. 1846
Small Irrigation Pumping Plants	Farmers' Bulletin No. 1857
Practical Irrigation	Farmers' Bulletin No. 1922
Irrigation of Sugar Beets Grown for Seed	Farmers' Bulletin No. 658
Drainage in Arid Regions	Yearbook Separate No. 1648

HOW WATER IS APPLIED TO CROPS

Water is applied to the soil in many ways. The best method to use in particular cases depends on topography, character of the soil, the water supply, kind of crop and the owner's experience. Irrigation practices vary in different parts of the country and even on farms in the same community. In too many cases all the farmers in a community use the same methods regardless of their suitability to the diverse conditions usually present in many large areas. The method of irrigation should be decided on and the operations planned accordingly before the farm distribution system is laid out, the preparation of land for irrigation is started, or perennial crops or trees are planted.

Difference in soils has a great influence on water use. While it is probable that crops grown on sandy soil do not actually use any more water than similar crops grown on heavier soils, the difficulty of preventing waste from percolation through the lighter soils makes it almost impossible for light-soil crops to get along with as small an irrigation supply as that given to others.

Water may be applied to crops either by gravity methods, that is, by allowing it to flow onto the land, or by sprinkler system, which requires the use of pipes and a certain amount of pressure. Only gravity methods will be discussed in this publication.

Delivery of water from the main canal or lateral usually is made at one or more high points on each farm unit. Some type of water-measuring device may be installed at these delivery points, as shown in figures 16 and 17, or a more complicated type, not shown here, may be used. On individual farms accurate measurements of irrigation water are being applied to different fields and avoid under-irrigation or over-irrigation and waste. Since irrigation water is, on many farms, a major item of expense, either directly on a measured basis or indirectly through power bills for pumping, good farm management requires that it be measured accurately. From the point of delivery the supply is carried to various fields by a system of farm laterals.

In some areas it is common practice to consider these laterals as permanent and to leave them in place year after year. The undisturbed ditchbanks provide a breeding place for grasshoppers, crickets, and other destructive insects and vermin, and provide a harbor for weeds and brush. Modern practice demands the plowing-in of these laterals at least once each year to destroy insects, vermin, and weeds.

Figure 1 shows various methods of applying irrigation water to field crops. Row crops are irrigated by furrows and borders, as shown in the upper left-hand corner of the figure. Close growing crops such as alfalfa are irrigated by border strips, corrugations or contour ditches as shown in the central part of the figure or by basins or border ditches, as shown in the lower part of the figure. Any one or a combination of the several methods may be best suited to an individual farm. The various methods of irrigating different crops are shown in more detail in figures 2 to 15, inclusive, along with details of the structures used.

IRRIGATION OF ROW CROPS

Irrigation of row crops usually is accomplished by allowing water to run down the furrow between rows. Field laterals are carried across the slope, as shown in figure 1, and water is distributed to the rows by various methods shown in figures 2 to 8, inclusive. The details and application of each method are depicted in the various figures.

To divert water from a field lateral, it is usually necessary to use some type of check dam to raise the water level. In figure 2 are shown two types of check dams. The metal-type check made of 16-gage galvanized iron is popular with irrigation farmers. It is ordinarily provided with an adjustable gate to bypass part of the supply. In light sandy soils it may be necessary to use a sack on the downstream side to prevent erosion as water flows through the gate. The canvas check is light and easily moved from place to place. The type shown is made with an outlet boot to bypass a part of the flow. The regulation is accomplished by opening or closing the drawstring. A few shovels of earth on the upstream side hold the canvas in position.

Accurate control of flow of irrigation water to row crops is very important under many conditions. The use of check dams, take-out boxes, and lath boxes or other forms of spiles permits accurate control of head and saves labor. Some irrigators cut the ditchbank with a shovel, allowing water to flow into the rows, with no method for controlling it. This practice usually results in some rows receiving too much water and others not enough. In certain soils and on some

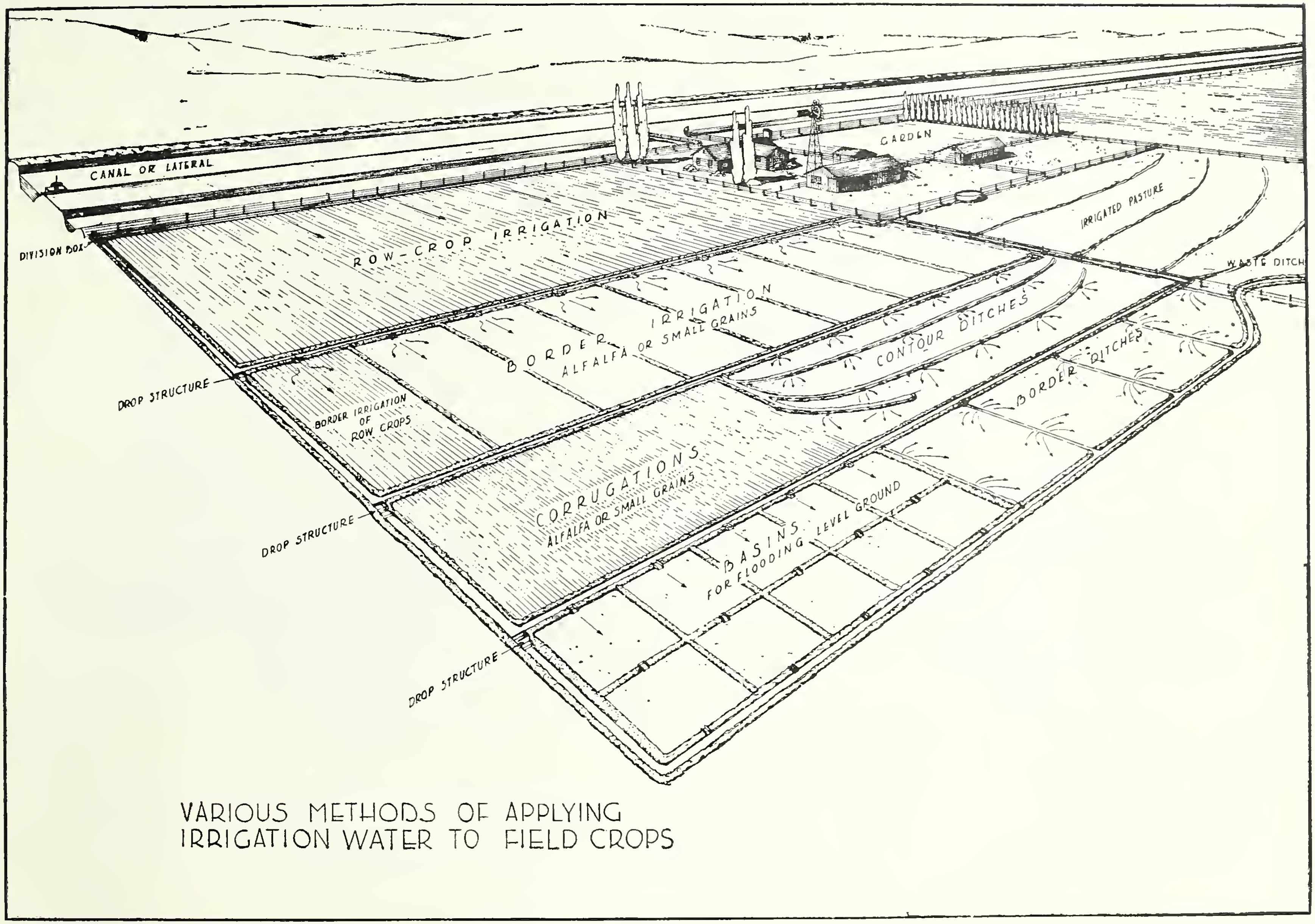

CANAL OR LATERAL
DIVISION BOX
ROW-CROP IRRIGATION
GARDEN
IRRIGATED PASTURE
WASTE DITCH
BORDER IRRIGATION
ALFALFA OR SMALL GRAINS
CONTOUR DITCHES
BORDER DITCHES
DROP STRUCTURE
BORDER IRRIGATION OF ROW CROPS
DROP STRUCTURE
CORRUGATIONS
ALFALFA OR SMALL GRAINS
BASINS
FOR FLOODING LEVEL GROUND
DROP STRUCTURE
VARIOUS METHODS OF APPLYING
IRRIGATION WATER TO FIELD CROPS

FIGURE 1.

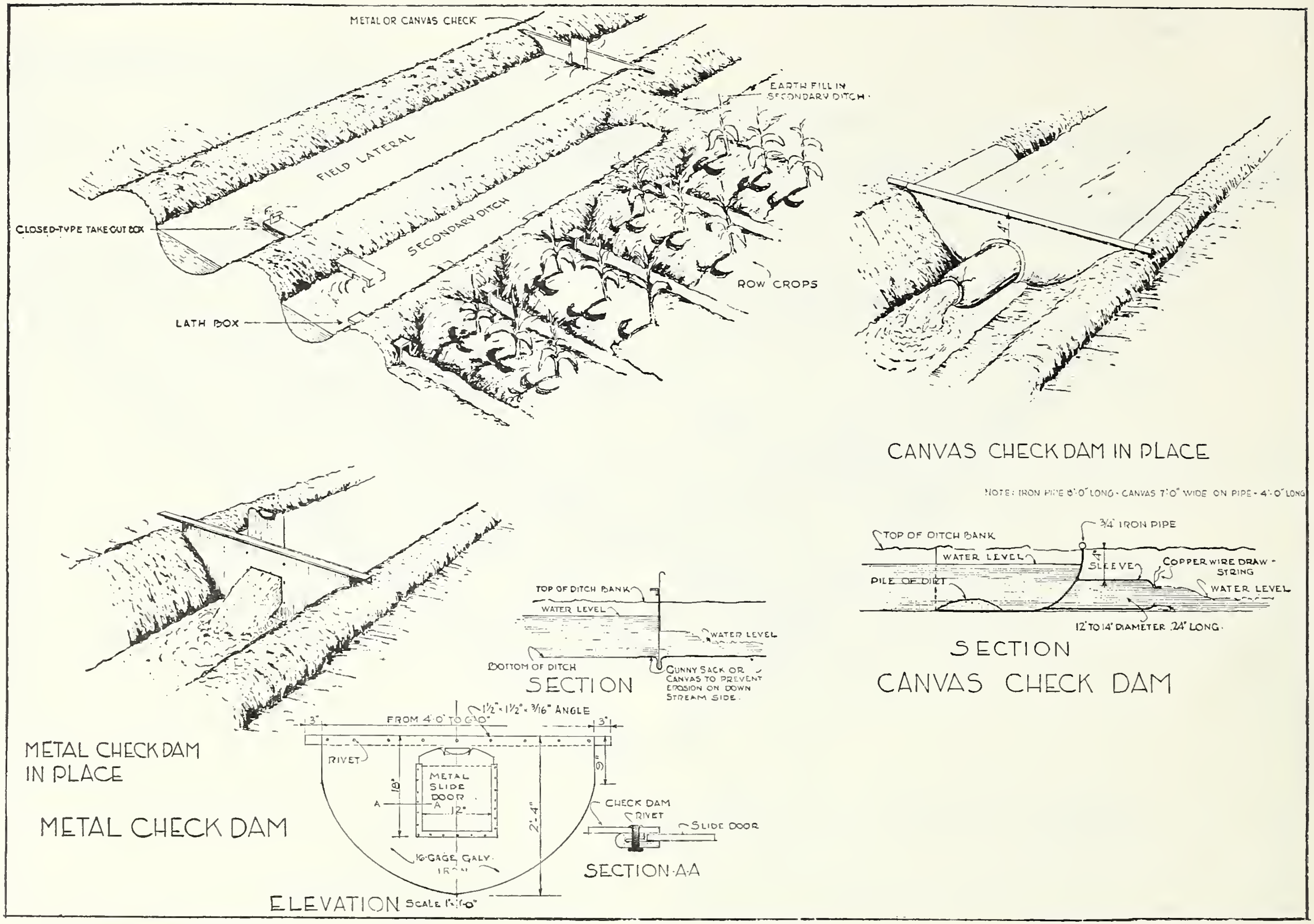

METAL OR CANVAS CHECK
EARTH FILL IN SECONDARY DITCH
FIELD LATERAL
SECONDARY DITCH
CLOSED-TYPE TAKE-OUT BOX
LATH BOX
ROW CROPS
CANVAS CHECK DAM IN PLACE
NOTE: IRON PIPE 8'-0" LONG - CANVAS 7'-0" WIDE ON PIPE - 4'-0" LONG
TOP OF DITCH BANK
3/4" IRON PIPE
WATER LEVEL
4'
SLEEVE
COPPER WIRE DRAW-STRING
PILE OF DIRT
WATER LEVEL
12" TO 14" DIAMETER 24" LONG.
SECTION
CANVAS CHECK DAM
TOP OF DITCH BANK
WATER LEVEL
WATER LEVEL
BOTTOM OF DITCH
SECTION
GUNNY SACK OR CANVAS TO PREVENT EROSION ON DOWN STREAM SIDE.
METAL CHECK DAM IN PLACE
METAL CHECK DAM
1½" × 1½" × 3/16" ANGLE
3"
FROM 4'-0" TO 6'-0"
3"
RIVET
9"
18"
METAL SLIDE DOOR
A
A
12"
2'-4"
16-GAGE GALV. IRON
CHECK DAM
RIVET
SLIDE DOOR
SECTION-A-A
ELEVATION SCALE 1"=1'-0"

FIGURE 2.

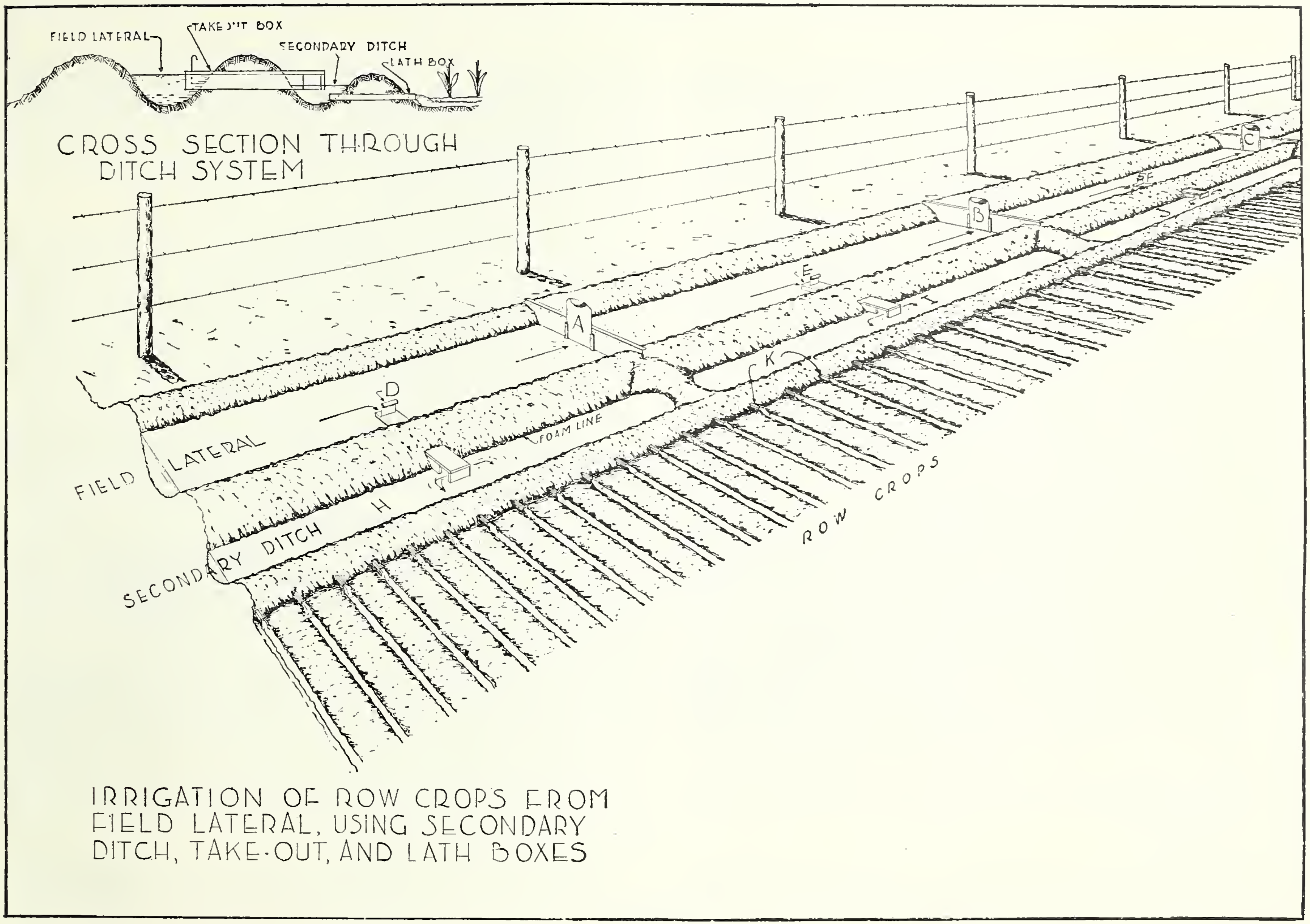

FIELD LATERAL
TAKE OUT BOX
SECONDARY DITCH
LATH BOX
CROSS SECTION THROUGH DITCH SYSTEM
C
F
B
J
E
I
A
K
D
FOAM LINE
FIELD LATERAL
H
SECONDARY DITCH
ROW CROPS
IRRIGATION OF ROW CROPS FROM FIELD LATERAL, USING SECONDARY DITCH, TAKE-OUT, AND LATH BOXES

FIGURE 3.

slopes heavy erosion is likely to occur between rows. By using the methods herein described the water supply can be controlled accurately and the operator can handle large heads of water with a minimum of effort and with effective results.

Figure 3 shows irrigation of row crops from a field lateral, using secondary ditch take-out and lath boxes. Water enters the field through the field lateral and is shown running from left to right, or away from the observer. The secondary ditch is made either with a plow or some form of ditcher. Small earth dams or checks are placed in secondary ditch as shown. The spacing depends upon the fall in the field laterals. The steeper the slope, the shorter the distance between the dams. General directions follow:

1. The metal check dam or canvas dam at *A* is set in the field lateral in order to raise the water so that it may be diverted from the field lateral to the secondary ditch at *H*. When the level is high enough, the bypass gate in the metal check is opened to let the excess water pass on down the field lateral.

2. The ditchbank is next cut with a shovel, and the take-out box at *D* is placed as shown. The box is well sealed with mud to keep it from leaking. The gate in the take-out box is opened to permit water to enter the regulation bay *H*.

3. Water standing in the secondary ditch will form a foam line. This foam line can be used as a guide in setting the lath boxes or spiles at a given level. Each lath box should be set as near level as possible and close to the ground in the row. Each box must be sealed around with mud. A lath box is generally set for each row, although where a small head is wanted, one box may serve two rows. There is less danger of the lath boxes getting clogged with trash if the water in the secondary ditch is kept above the level of the top of the boxes.

4. One take-out box will ordinarily serve from 12 to 20 lath boxes. The gate in the take-out box is opened to allow the desired flow of water through the lath box. The amount of water flowing through the lath box will depend on the height of the water above it. The gate in the check dam at *A* is then accurately set to maintain the proper head in the field lateral.

5. After one secondary ditch has been set, the same process is repeated in the second ditch as shown at *I*, and so on until the entire head in the field lateral is used.

Take-out Boxes

Take-out boxes are used to run water through the bank of a lateral to a secondary ditch and to control the flow. In the design shown in figure 4 is a closed-type take-out box. The side pieces of 1″ x 6″ material are cut 6″ shorter than the top and bottom pieces. One of the 6″ x 6″ blocks is nailed in the outlet end to form two side openings. Water flowing from the two side openings prevents erosion of the opposite bank. By raising and lowering the metal door at the entrance end of the box, the flow of water into the secondary ditch can be controlled.

Lath Boxes

Spiles are used to run water through the secondary ditch bank to the rows. There are many forms of spiles in use in irrigated sections but the lath box here shown is both cheap and convenient. It is made by nailing four full length laths together as shown in figure 4 and sawing at the center to form two boxes each about 2 feet long. The laths are staggered at the entrance and to prevent clogging with leaves or trash. It is advisable to use galvanized nails and to treat the boxes with creosote or to soak them 24 hours in used crankcase oil.

In irrigation of row crops the use of the closed-type take-out box, secondary ditch, and lath boxes, permits a uniform, controlled distribution of water to each row and is more saving of labor than the old method of cutting the ditchbank and attempting to guide water into each row with a shovel.

Approximate-contour Method

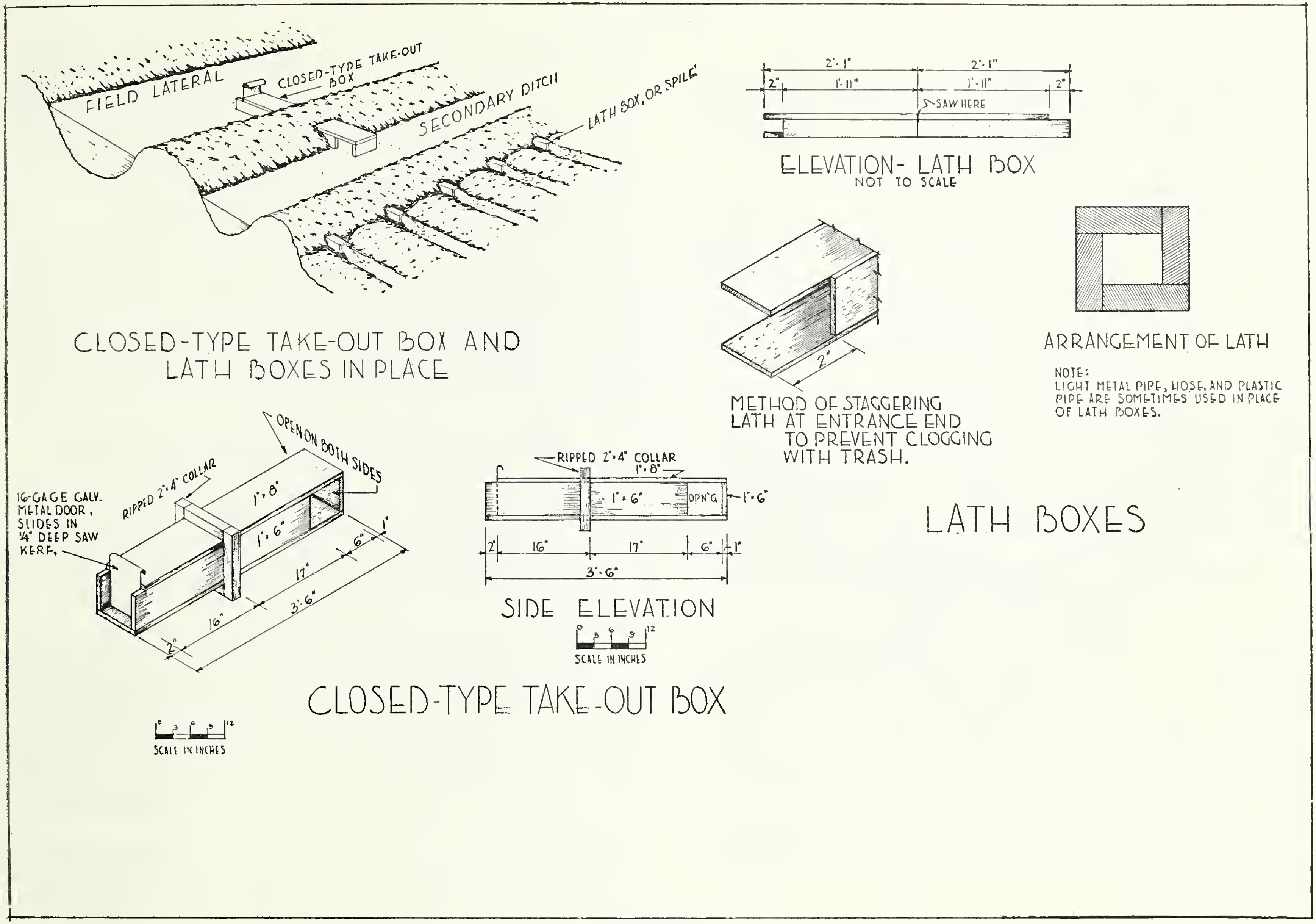
It is sometimes desirable to carry a lateral down the side of a field and to run the water across the slope approximately on the contour. Figure 5 shows this method of irrigation. Check dams such as those shown at points *A* and *B* are used as drops and are spaced according to the steepness of the slope.

A number of small checks, which may be made with shingles, are placed in the secondary ditch. Small earth dams may also be used at intervals in the secondary ditch. To help in obtaining a balance of water in the various parts of the secondary ditch, a lath box, as shown at *G*, may be placed through the earth dams.

The take-out boxes are placed just above the check dam in order to take advantage of the greater depths of water at that point. The lath boxes are set through the bank of the secondary ditch.

Row Crops With Turnrow

Arrangements for irrigating row crops will vary, depending upon location, type of crop, soil, and so on. When crops are planted which



CLOSED-TYPE TAKE-OUT BOX AND LATH BOXES IN PLACE

CLOSED-TYPE TAKE-OUT BOX

ELEVATION- LATH BOX
NOT TO SCALE

METHOD OF STAGGERING LATH AT ENTRANCE END TO PREVENT CLOGGING WITH TRASH.

ARRANGEMENT OF LATH

NOTE:
LIGHT METAL PIPE, HOSE, AND PLASTIC PIPE ARE SOMETIMES USED IN PLACE OF LATH BOXES.

SIDE ELEVATION

LATH BOXES

FIGURE 4.

will need cultivation during the irrigating season, a turnrow is sometimes used between the field lateral and the secondary ditch to give the irrigator room for turning equipment. Figure 6 shows the layout of the field lateral and the secondary ditch with a turnrow between. Note that the take-out box is turned so that the gate end is towards the secondary ditch and can be regulated from that side.

Irrigation of Row Crops by Means of Siphon Tubes

An arrangement for irrigating row crops by use of siphon tubes is shown in figure 7. Siphon tubes made of light metal or plastics are sometimes used to run water from a field lateral to furrows for irrigation of row crops. Some irrigators prefer this method, since it is not necessary to cut the ditchbank to place tubes and the use of a secondary ditch is not required. It has the disadvantage of being difficult to regulate, and if flow in the lateral is interrupted the siphon action in all tubes must be started again.

The siphon action is started as follows:

1. The tube is filled with water by submerging it in the canal.
2. The hand is placed over one end and the tube set in position, as shown in the drawing.
3. When the hand is removed the flow may be adjusted by raising or lowering the discharge end.
4. The intake end of the tube should be placed far enough under water to eliminate clogging by floating trash.

SUPPLYING WATER TO DITCHES BY UNDERGROUND PIPE

Sometimes water is supplied by an underground-pipe system with outlets through orchard or alfalfa valves. Water flowing from the alfalfa or orchard valve onto sandy soil will often erode the ditchbank as it flows into the ditch. One satisfactory method of eliminating erosion and directing water into the ditch is by use of a top box. The top box is enclosed on three sides and is fitted around the valve and riser pipe high enough above the ground so that the water will not run over the top of the box. As the water is released from the valve it enters the ditch through the side opening in the box. The boxes are portable and can be moved from place to place. Figure 8 shows top boxes in place and also a drawing of the box. A table with the drawings gives the dimensions of various size boxes needed for valves of different sizes.

IRRIGATION BY USE OF GATED SURFACE PIPE

Land is sometimes irrigated by using an underground-pipe supply system and gated surface pipe. This method is used in parts of the country where there are high crop returns per acre. The system is expensive to install but has several advantages. It can be used on rolling topography where ditches often would not be practical. The use of gated surface pipe makes a saving in labor costs.

Figure 9 illustrates this method of irrigation. The water is turned into the main supply pipe *A*. Valve*B* is partly or completely closed. Valve *C* is opened, and water runs into the supply pipe to hydrants. The metal, gated, surface pipe is joined together and connected to the portable or permanent hydrant *D*. As the hydrant *D* is opened, water flows into the portable pipe *E*. Water is released from the pipe into the furrows by means of adjustable metal gates. In practice the lower end of the field is irrigated first, the operation progressing uphill so there will be dry soil upon which to work when laying the surface pipe.

IRRIGATION OF CLOSE-GROWING CROPS

Close-growing crops such as small grain, sorghums, and alfalfa, may be watered by border dikes or corrugations (fig. 10) or by contour ditches (fig. 12). As in the case of row crops, control of the supply is important if best results are to be obtained with the least effort. Corrugations are best adapted to steep slopes and contour ditches to land with an irregular surface and no well defined slope direction.

On fields with uniform slopes of less than 3 feet per 100 feet, border dikes may be used to good advantage. The spacing of dikes will vary with conditions of soils, slope, and the head of water available. Under average conditions a spacing of 40 to 50 feet will be found sufficient. It is very important that the dikes run directly down the slope and that the ground surface between them be well leveled. When contour ditches are used, the original lay-out must be carefully done. The spacing between ditches varies from 200 feet on slopes of 5 to 8 feet per 100, to 400 feet or more on heavy soils with slopes of 1 foot per 100 feet or less.

Much of the drainage trouble experienced in many irrigated sections is caused by excessive use of irrigation water. Streams are allowed to run down rows or between border dikes and out into road ditches for

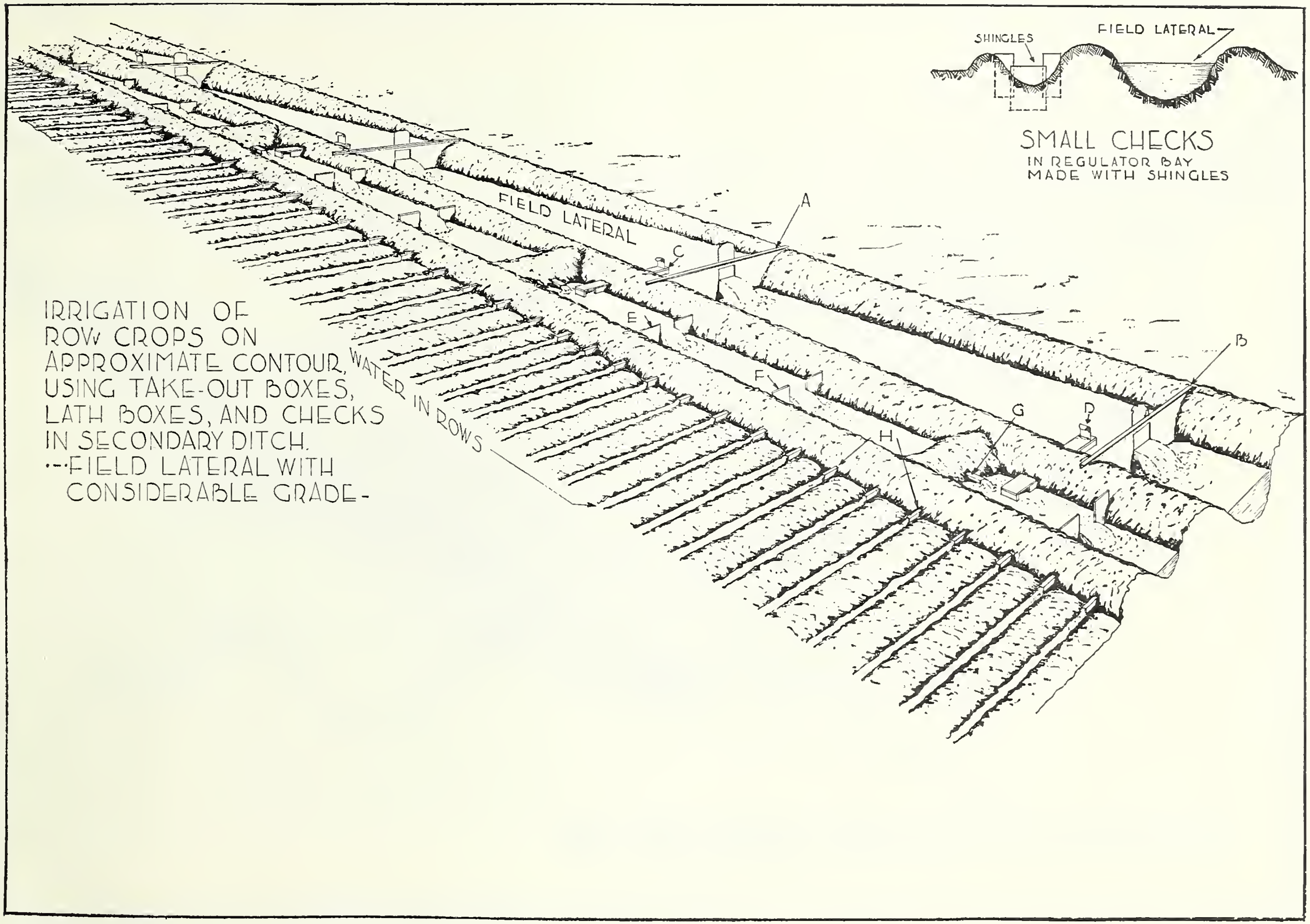
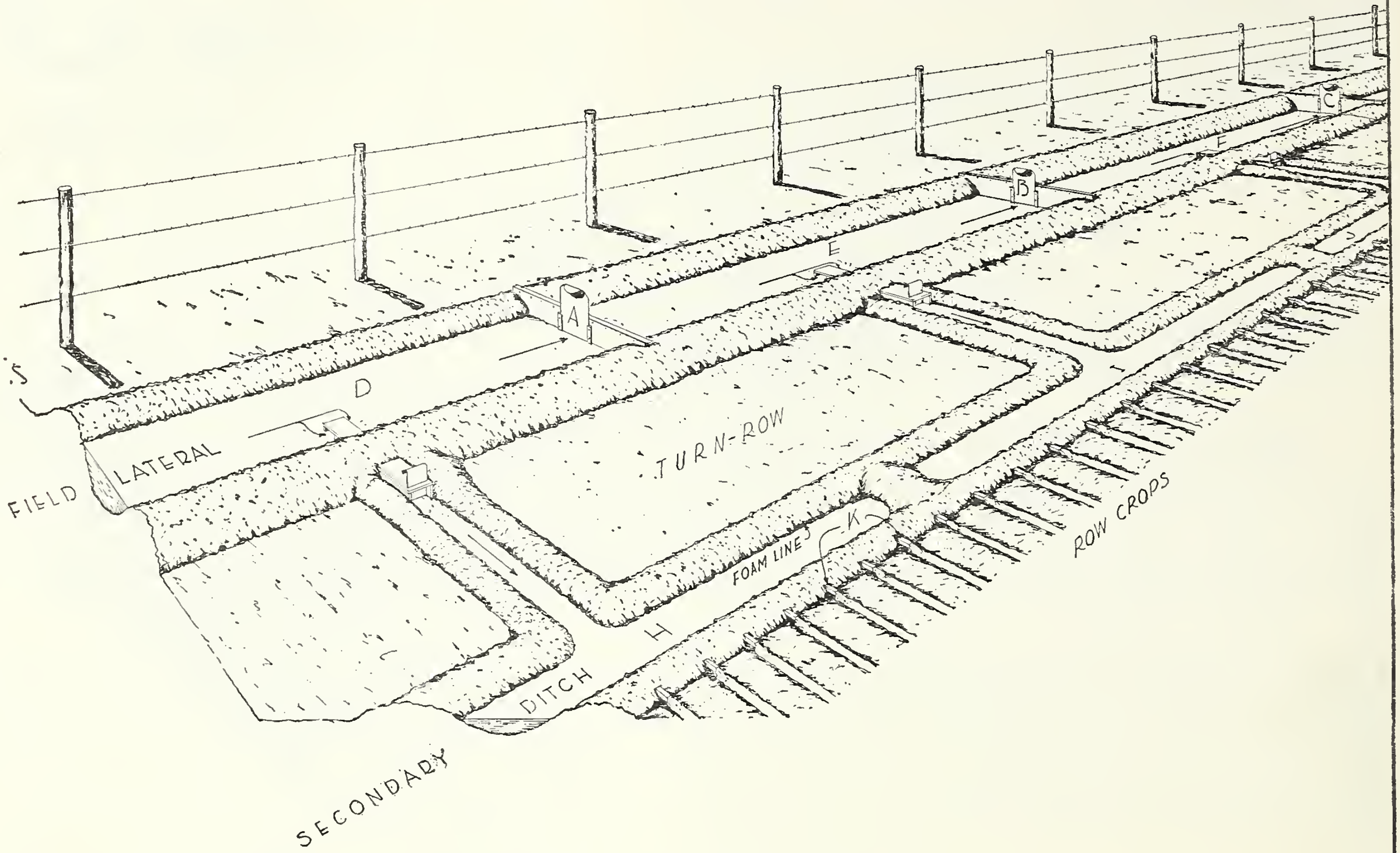

SHINGLES
FIELD LATERAL
SMALL CHECKS
IN REGULATOR BAY
MADE WITH SHINGLES
FIELD LATERAL
A
C
E
F
G
D
B
H
WATER IN ROWS
IRRIGATION OF
ROW CROPS ON
APPROXIMATE CONTOUR,
USING TAKE-OUT BOXES,
LATH BOXES, AND CHECKS
IN SECONDARY DITCH.
--FIELD LATERAL WITH
CONSIDERABLE GRADE-

Figure 5.



IRRIGATION OF ROW CROPS, USING A TURN-ROW
BETWEEN FIELD LATERAL AND SECONDARY DITCH

Figure 6.

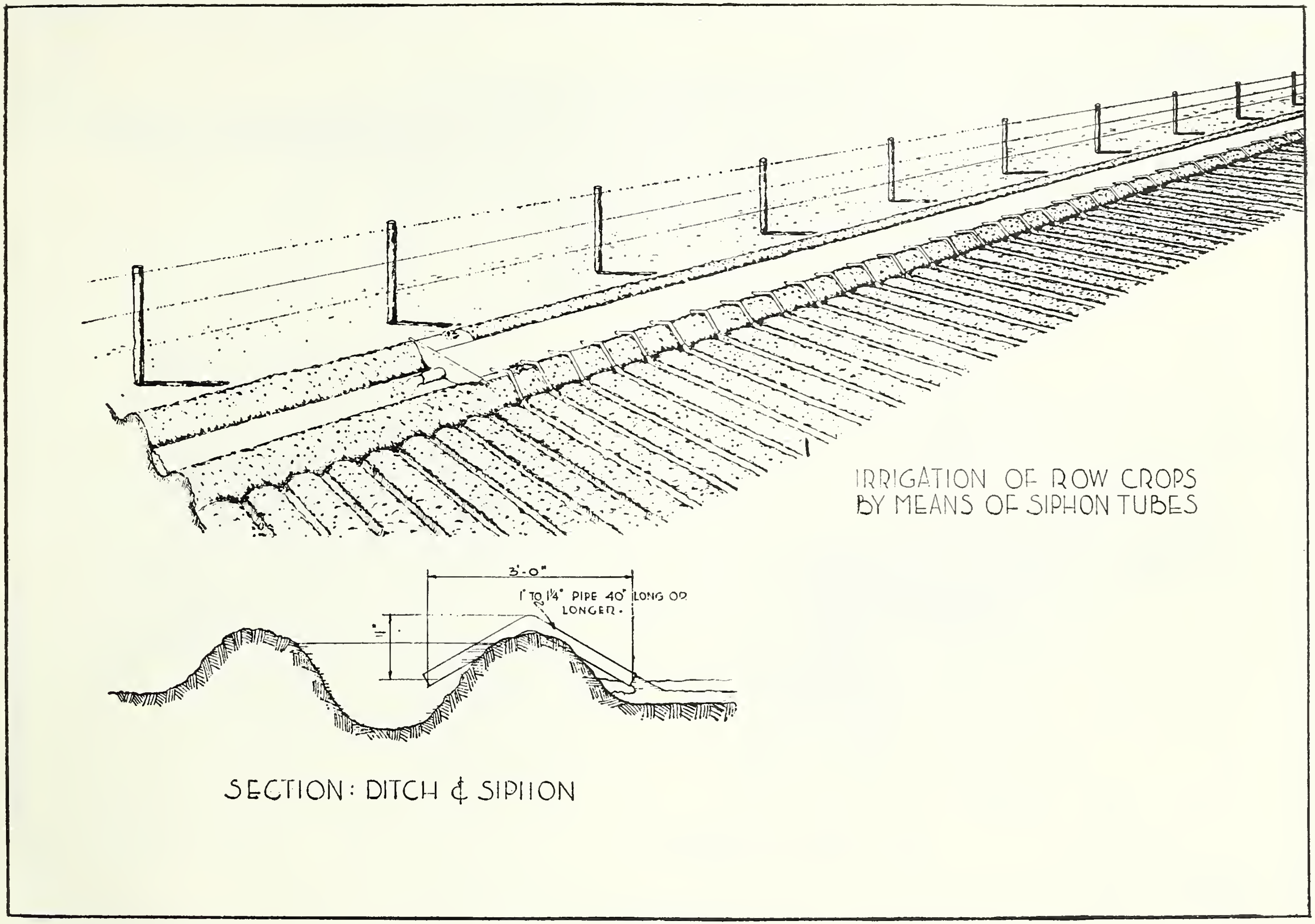
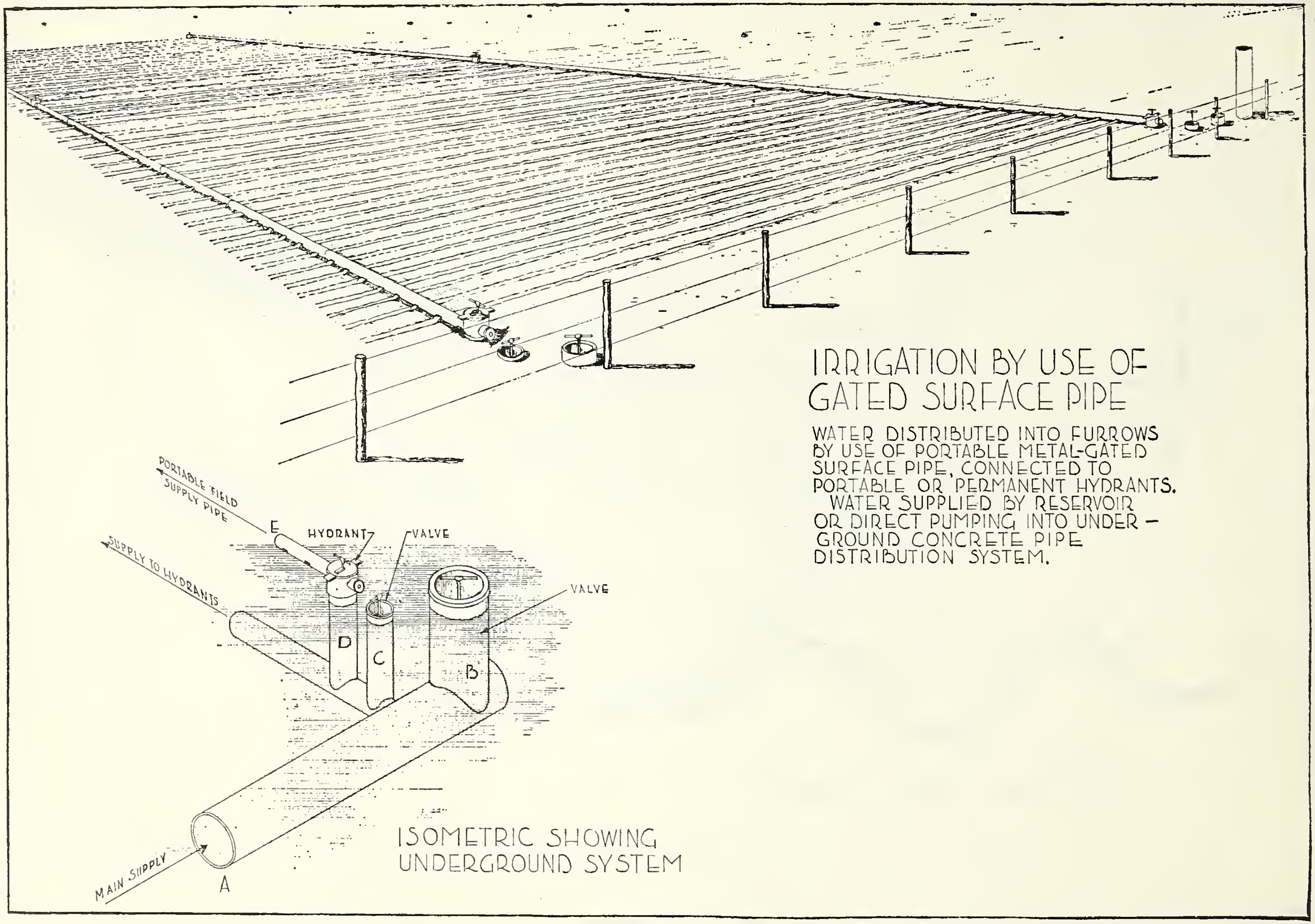

IRRIGATION OF ROW CROPS BY MEANS OF SIPHON TUBES
3'-0"
1" TO 1¼" PIPE 40" LONG OR LONGER.
1'
SECTION: DITCH & SIPHON

FIGURE 7.

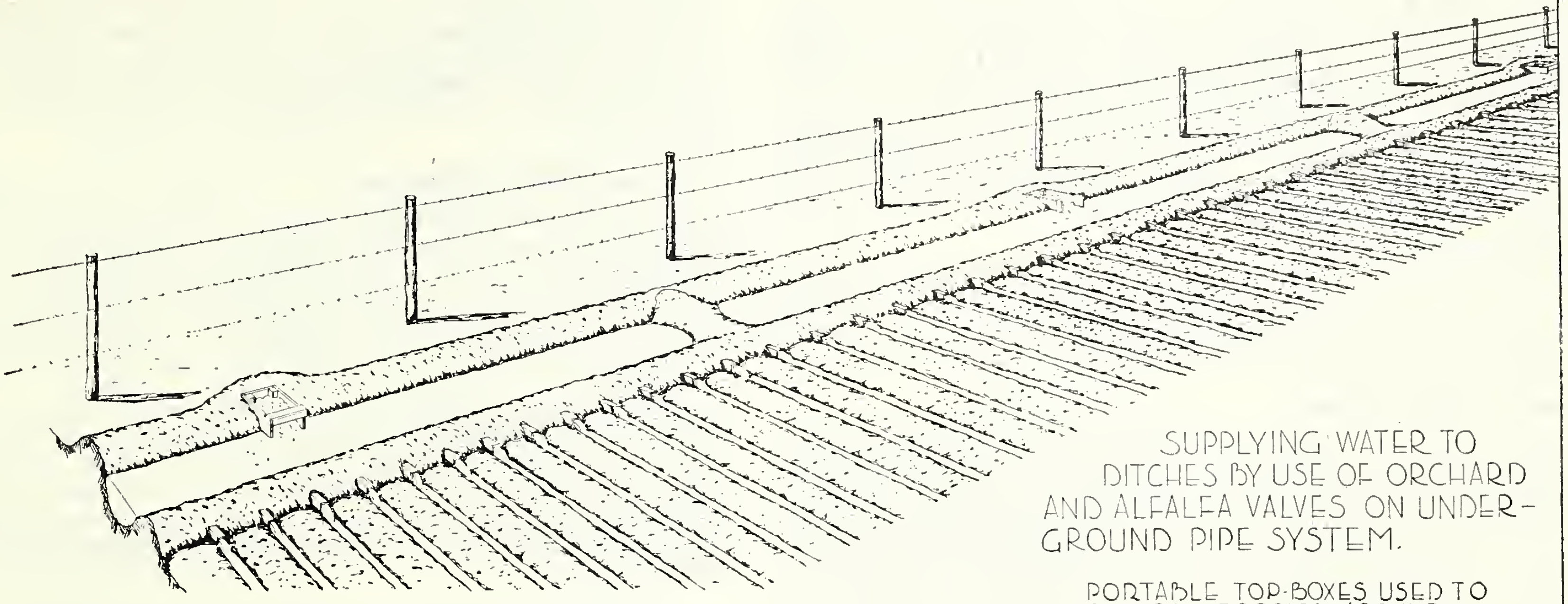

PORTABLE FIELD SUPPLY PIPE
SUPPLY TO HYDRANTS
E
HYDRANT
VALVE
VALVE
D
C
B
MAIN SUPPLY
A
ISOMETRIC SHOWING UNDERGROUND SYSTEM

IRRIGATION BY USE OF GATED SURFACE PIPE

WATER DISTRIBUTED INTO FURROWS BY USE OF PORTABLE METAL-GATED SURFACE PIPE, CONNECTED TO PORTABLE OR PERMANENT HYDRANTS.

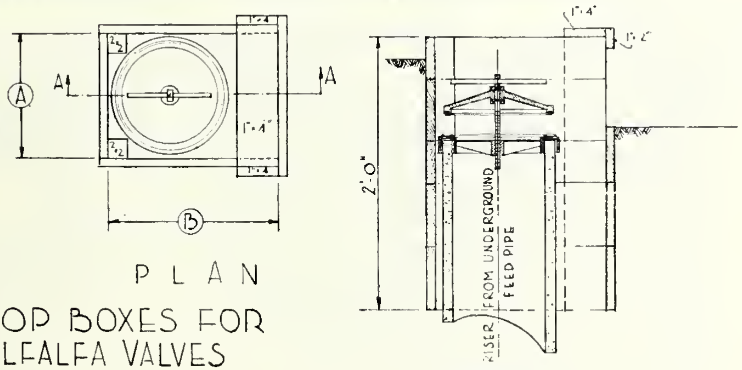
WATER SUPPLIED BY RESERVOIR OR DIRECT PUMPING INTO UNDERGROUND CONCRETE PIPE DISTRIBUTION SYSTEM.

Figure 8.



SUPPLYING WATER TO DITCHES BY USE OF ORCHARD AND ALFALFA VALVES ON UNDERGROUND PIPE SYSTEM.

PORTABLE TOP-BOXES USED TO CONTROL EROSION AROUND VALVES ON SANDY SOIL, AND TO DIRECT FLOW OF WATER INTO IRRIGATION DITCHES



P L A N

SECTION A-A.

TOP BOXES FOR ALFALFA VALVES

BOX-DIMENSIONS SCHEDULE.

SIZE OF RISER	BOX DIMENSIONS	
	Ⓐ	Ⓑ
8"	11"	15"
10"	13"	17"
12"	16"	20"
14"	18"	24"
16"	20"	26"

FIGURE 9.

hours longer than is necessary. As a result of improper spacing of field laterals some parts of a field are overirrigated, causing a rise in the underground water level. Figure 13 illustrates a method of irrigating row crops in which excess water is gathered in other field laterals and redistributed to other parts of the same farm. The same principle here illustrated may be employed when using border ditches, border dikes, or corrugations. The fact that an irrigator has a legal right to a certain quantity of water should not influence him to use it wastefully with loss to himself and the community at large.

Corrugation Method

The corrugation method of irrigation, shown in figure 10, is used for watering close-growing crops on steep slopes or for new fields which have not been completely leveled. The corrugations are made with a corrugator, such as that shown in figure 26.

Border-dike Method

The border-dike method of irrigation (fig. 10) is used for watering close-growing crops such as small grain and hay on slopes which do not exceed 2 to 3 feet per 100 feet. The dikes which guide the water down the border are built with the border drag shown in figure 28 or with special machines. The dikes are laid out down the steepest slope and the strip leveling is done with the leveler float (fig. 24), but it may be finished with the buck scraper (fig. 23), used after the water is turned in and the high and low spots show up. Water is run onto the border strip from the field lateral through open type outlet boxes which are described in figure 11.

Open-Type Outlet Box

The open-type outlet box shown in figure 11 is used primarily for diverting water into the upper end of the border strip from a field lateral. The gate in the box can be raised or lowered to control the flow from the field lateral to the border strip. Using the outlet box is much better than just making a cut in the lateral bank. Water flowing through a cut in the ditchbank causes erosion and is hard to control. The outlet box provides a means of controlling the flow of water and prevents erosion. Structures of this type should be nailed with galvanized or cement-coated nails.

Check Boxes

In addition to the temporary checks shown in figure 2, it is often desirable to have permanent checks installed in canals and field laterals at points where diversions are made. The check box shown in figure 11 is made of creosote-treated material nailed together with galvanized cement-coated nails. It is provided with small check boards which permit any desired head to be carried in the lateral. Earth must be tightly compacted around the structure if undercutting is to be prevented.

Contour-Ditch Irrigation

The use of contour-ditch irrigation is favored in many sections for watering small grain, pasture, and hay on irrigation slopes in excess of 2 or 3 percent. The success of the system depends upon the care with which the contour laterals are placed. It is customary to build the ditches across the slope with no grade or with less than one-tenth of 1 foot per 100 feet. The contour ditch method is illustrated in figure 12.

In some cases water is brought to the land directly from the contour ditch. A better method consists of placing a furrow on the lower side of the contour ditch throwing the furrow slice uphill. The flow is diverted from the contour ditch to the furrow by means of take-out boxes. Water spilling over the lip of the furrow pours down over the slope in a uniform sheet if the system has been carefully laid out and constructed.

USE OF EXCESS WATER IN IRRIGATION

It is the practice on many irrigated lands to let a head of water run through rows or borders and be wasted at the lower end of the field by running into roadside ditches or elsewhere. This is a common cause of poor drainage on the land, and it wastes time and money. Care in planning the arrangement of fields and pasture and laying out irrigation systems can save both water and labor.

Figure 13 shows how an irrigation system may be laid out for greater use of irrigation water. A set may be made at *A* and rows irrigated from lateral *D* down the slope toward lateral *E*. The waste water is collected above lateral *E* and cut into it at *X*. This excess water is used to irrigate additional rows at *B* and the excess water used at *C*. The same practice may be applied in the case of border or corrugation. By careful arrangement of fields and pasture the waste water from one portion of the farm may be economically applied elsewhere.

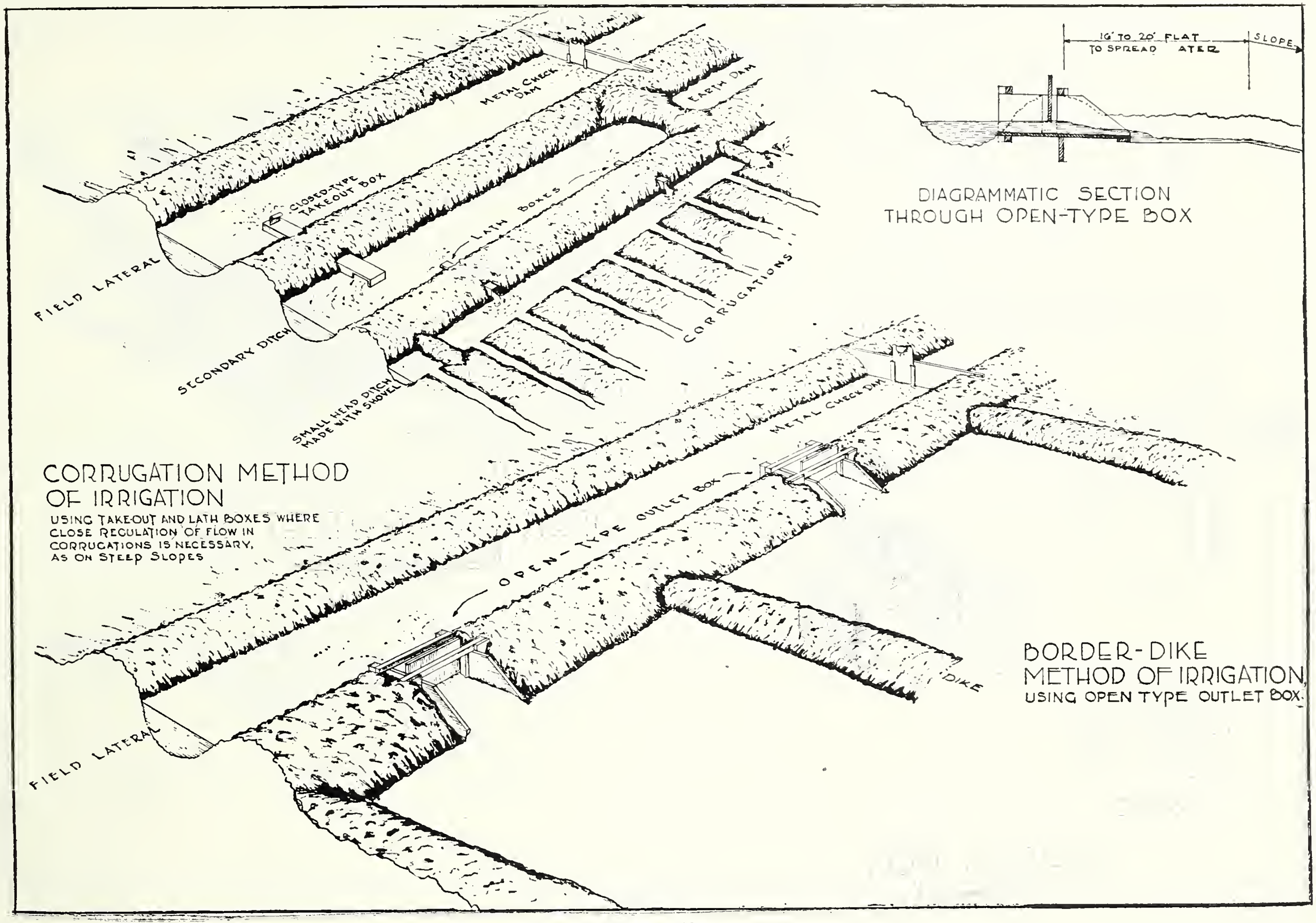

16' TO 20' FLAT TO SPREAD WATER
SLOPE
DIAGRAMMATIC SECTION THROUGH OPEN-TYPE BOX
METAL CHECK DAM
EARTH DAM
CLOSED-TYPE TAKEOUT BOX
LATH BOXES
FIELD LATERAL
SECONDARY DITCH
CORRUGATIONS
SMALL HEAD DITCH MADE WITH SHOVEL
CORRUGATION METHOD OF IRRIGATION
USING TAKE-OUT AND LATH BOXES WHERE CLOSE REGULATION OF FLOW IN CORRUGATIONS IS NECESSARY, AS ON STEEP SLOPES
METAL CHECK DAM
OPEN-TYPE OUTLET BOX
DIKE
FIELD LATERAL
BORDER-DIKE METHOD OF IRRIGATION, USING OPEN TYPE OUTLET BOX.

FIGURE 10.

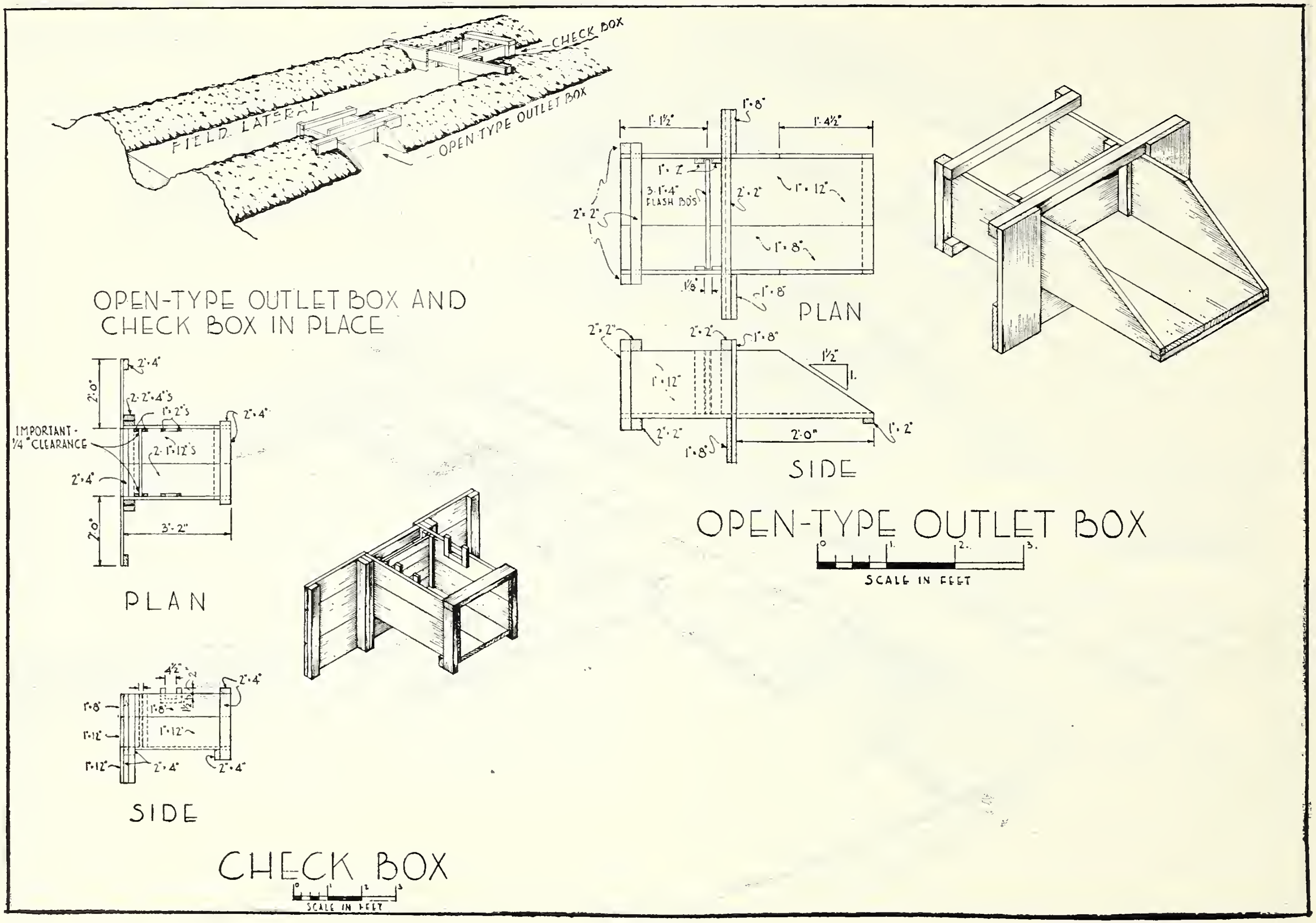

CHECK BOX
FIELD LATERAL
OPEN-TYPE OUTLET BOX
OPEN-TYPE OUTLET BOX AND CHECK BOX IN PLACE
1'·1½"
1'·8"
1'·4½"
1'·2"
3-1'·4" FLASH BD'S
2'·2"
1'·12"
1'·8"
2"·2"
1½"
1'·8"
PLAN
2"·2"
2"·2"
1'·8"
1½
1.
1'·12"
2"·2"
1'·8"
2'·0"
1'·2"
SIDE
OPEN-TYPE OUTLET BOX
0
1.
2.
3.
SCALE IN FEET
2"·4"
2'·0"
2-2"·4"S
1"·2"S
2"·4"
IMPORTANT - 1/4" CLEARANCE
2-1"·12"S
2"·4"
2'·0"
3'-2"
PLAN
4½"
2"·4"
1"·8"
1"·8"
1"·12"
1"·12"
1"·12"
2"·4"
2"·4"
SIDE
CHECK BOX
0
1
2
3
SCALE IN FEET

Figure 11.

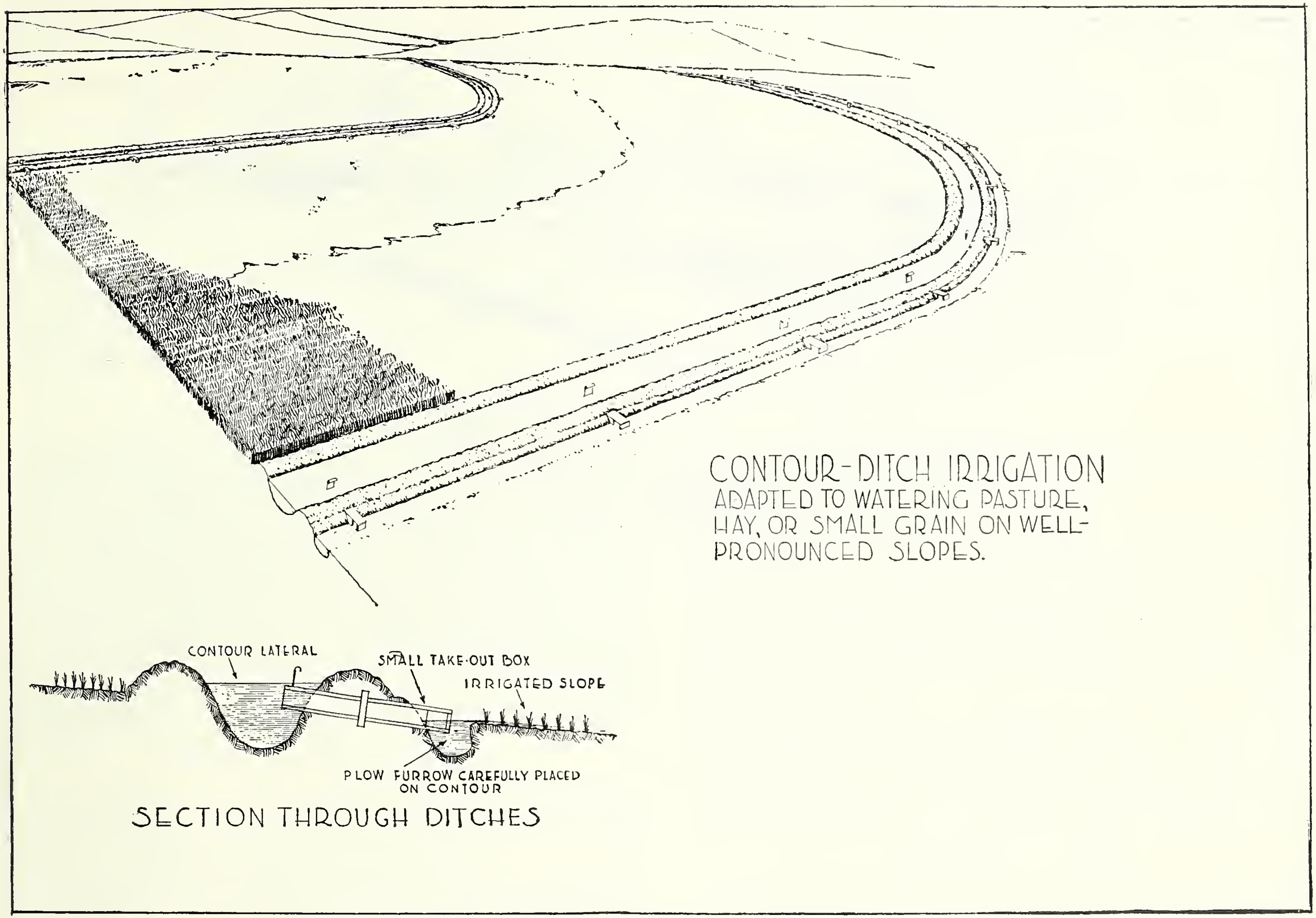

CONTOUR-DITCH IRRIGATION
ADAPTED TO WATERING PASTURE, HAY, OR SMALL GRAIN ON WELL-PRONOUNCED SLOPES.
CONTOUR LATERAL
SMALL TAKE-OUT BOX
IRRIGATED SLOPE
PLOW FURROW CAREFULLY PLACED ON CONTOUR
SECTION THROUGH DITCHES

FIGURE 12.

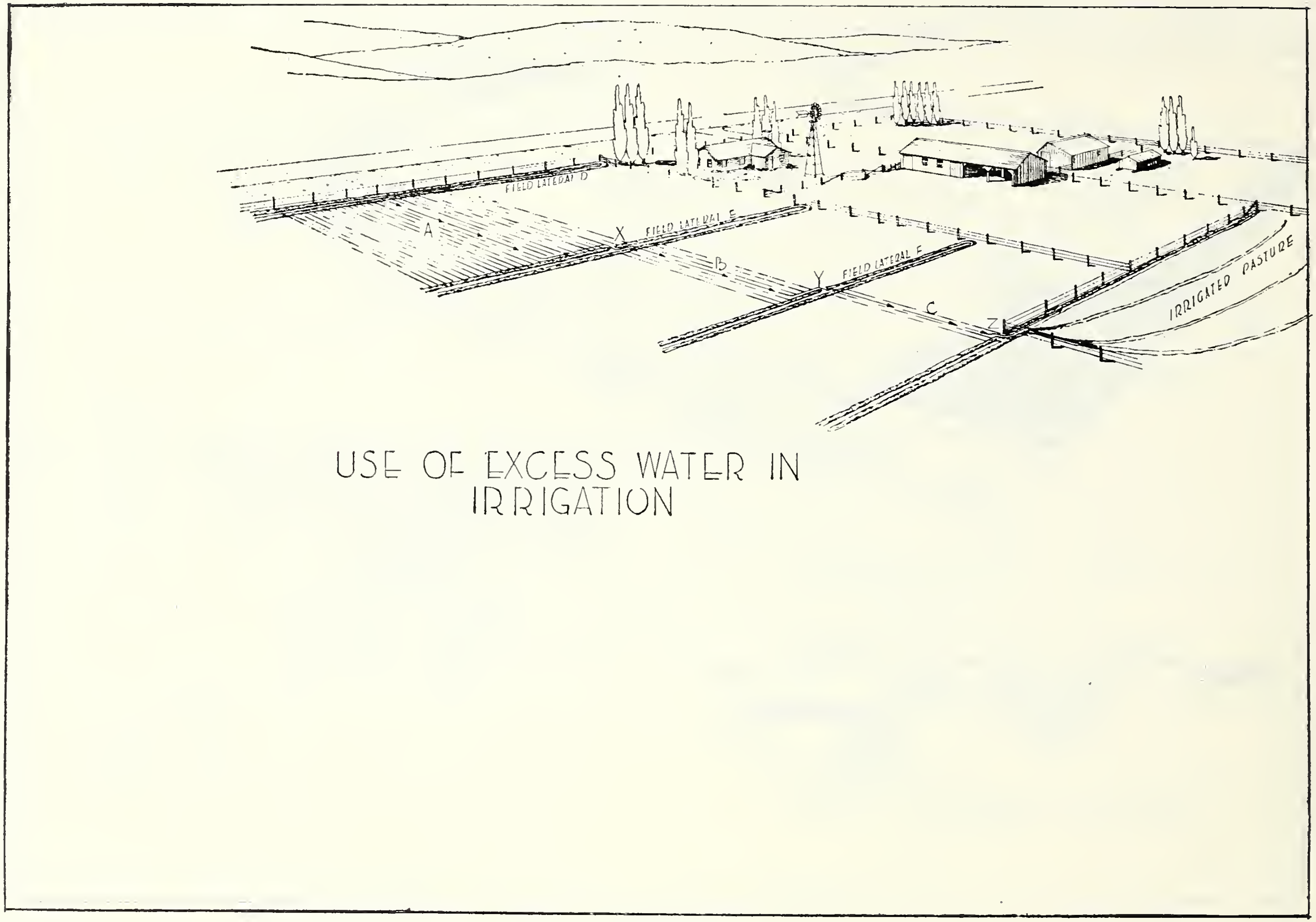

FIELD LATERAL D
A
X
FIELD LATERAL E
B
Y
FIELD LATERAL F
C
Z
IRRIGATED PASTURE
USE OF EXCESS WATER IN IRRIGATION

Figure 13.

CONTOUR-FURROW METHOD OF ORCHARD IRRIGATION

The planting of orchard rows approximately on the contour increases the efficiency with which irrigation water may be applied and eliminates a serious erosion problem. In some cases underground pipe lines have been installed to deliver water to furrows, as shown in figure 14.

The supply from the pipe line is controlled by a valve which is hand operated. The division of the flow to the furrows is made by means of small check dams and lath boxes.

The furrows between tree rows may be made with the torpedo-type furrow opener shown in figure 27, page —.

APPLICATION OF WATER IN ORCHARDS ON BENCH TERRACES

The planting of orchards in contour bench terraces on steep slopes prevents erosion and saves labor in applying irrigation water. The width of benches depends on the spacing of tree rows and also somewhat on the slope.

Irrigation water may be supplied by a canal provided with a series of drops and outlet boxes or by means of a pipe line.

In figure 15 the canal is shown with drop structures (fig. 18) and open-type outlet boxes (fig. 11). Each bench may be sloped slightly toward the hill to provide a channel, or a series of furrows may be used (fig. 14). Care must be used to provide a protected channel for removal of excess irrigation water, or serious erosion may result.

IRRIGATION STRUCTURES

Farm irrigation structures consist of water-measuring devices, drops, flumes, spiles, checks, and division boxes. Wooden structures sometimes are preferred in temporary farm ditches because they can be removed easily when it becomes necessary to clean the ditch or to plow the banks to destroy insects or weeds. The use of well-designed and well-placed structures may save a great deal of labor. Measuring devices allow an irrigation farmer to know how much water is being applied and to determine if he is receiving his full allotment. Drops in a ditch line prevent erosion while take-out boxes, checks, and division boxes aid greatly in the everyday tasks of handling water.

In addition to the larger farm structures mentioned, there are many minor ones, such as lath boxes or spiles, take-out boxes, and metal and canvas checks (figs. 2 and 4), all of which aid the irrigator in making a uniform distribution of water in quantities suited to the conditions at hand.

RECTANGULAR WEIR

The rectangular weir shown in figure 16 is an easily constructed measuring device for determining the amount of water used by an irrigator. Unless certain general rules are followed in its use and construction, accurate results will not be obtained.

The wall of the weir should be set plumb vertically and level horizontally, as well as at right angles to the direction of flow of the stream. It shoud be placed in a part of the channel which is straight for a distance of 25 feet upstream. In order that water shall not approach the weir at a velocity of more than ½ foot per second, it may be necessary to widen the cross section of the channel somewhat, as shown in figure 16.

The height of the crest or bottom of the weir notch above the stream bed on the upstream side of the weir should be at least twice the head to be measured. In other words, D should equal two times H. The distance from the sides of the weir notch to the sides of the bank should be at least twice the head to be measured, or two times H.

A rule or scale for measuring the head, H, may be attached to a stake set at the side of the channel and some distance upstream. The *0* point on the scale should be set on a level with the weir crest, as shown. This may be done with an engineer's level or a straightedge and a carpenter's level.

Ordinarily this type of weir should not be combined with outlet boxes, drops, or other structures for best results. A collection of silt on the upstream side of the weir will affect accuracy of results.

To measure flow over the weir, read the depth indicated on the scale in decimals of a foot, or in inches. Read the flow in cubic feet per second or gallons per minute, directly from the table in figure 16.

PARSHALL FLUME

The Parshall flume shown in figure 17 is a commonly used measuring device for determining the amount of water flowing in a canal or

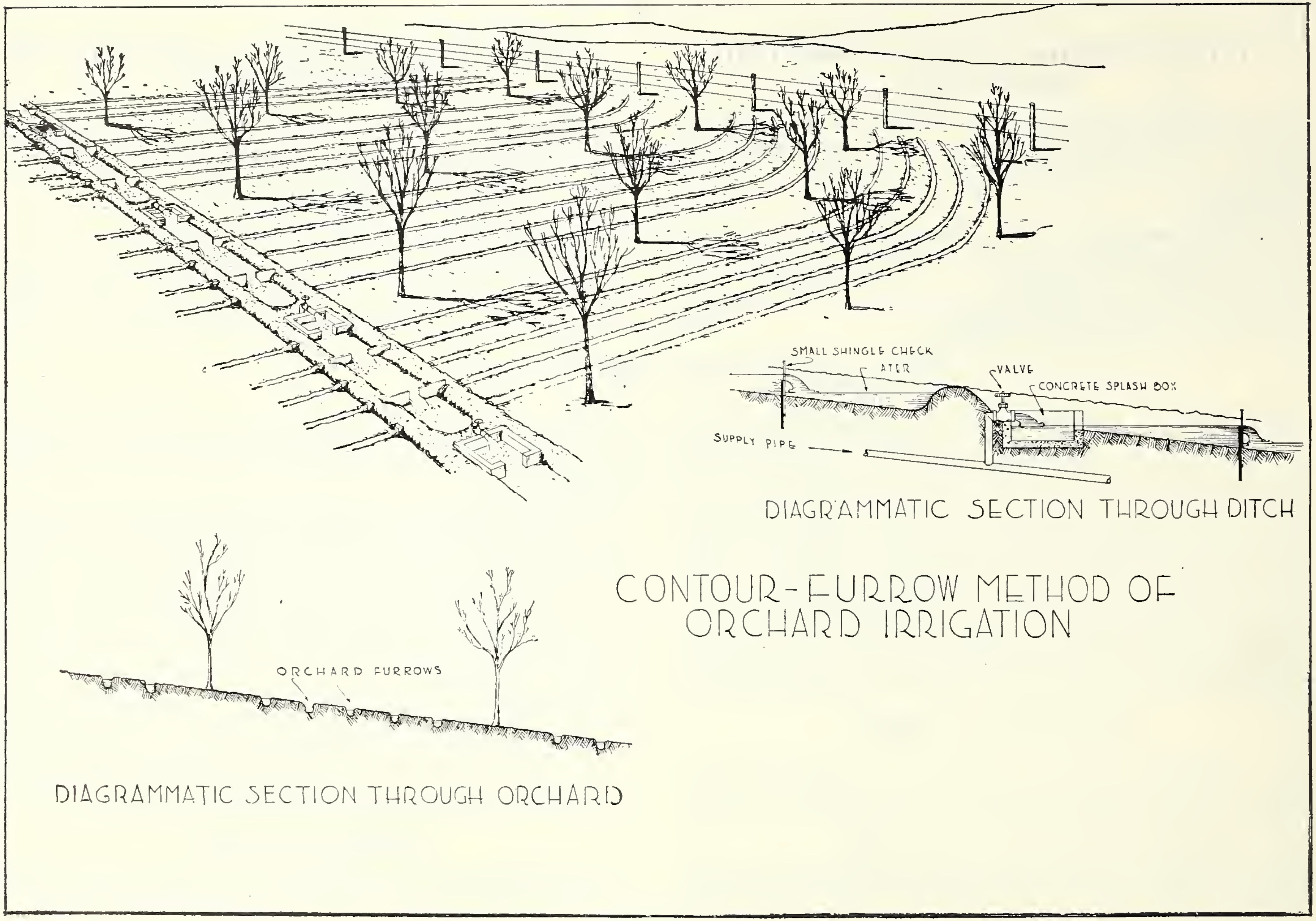

SMALL SHINGLE CHECK
ATER
VALVE
CONCRETE SPLASH BOX
SUPPLY PIPE
DIAGRAMMATIC SECTION THROUGH DITCH
CONTOUR-FURROW METHOD OF ORCHARD IRRIGATION
ORCHARD FURROWS
DIAGRAMMATIC SECTION THROUGH ORCHARD

Figure 14.

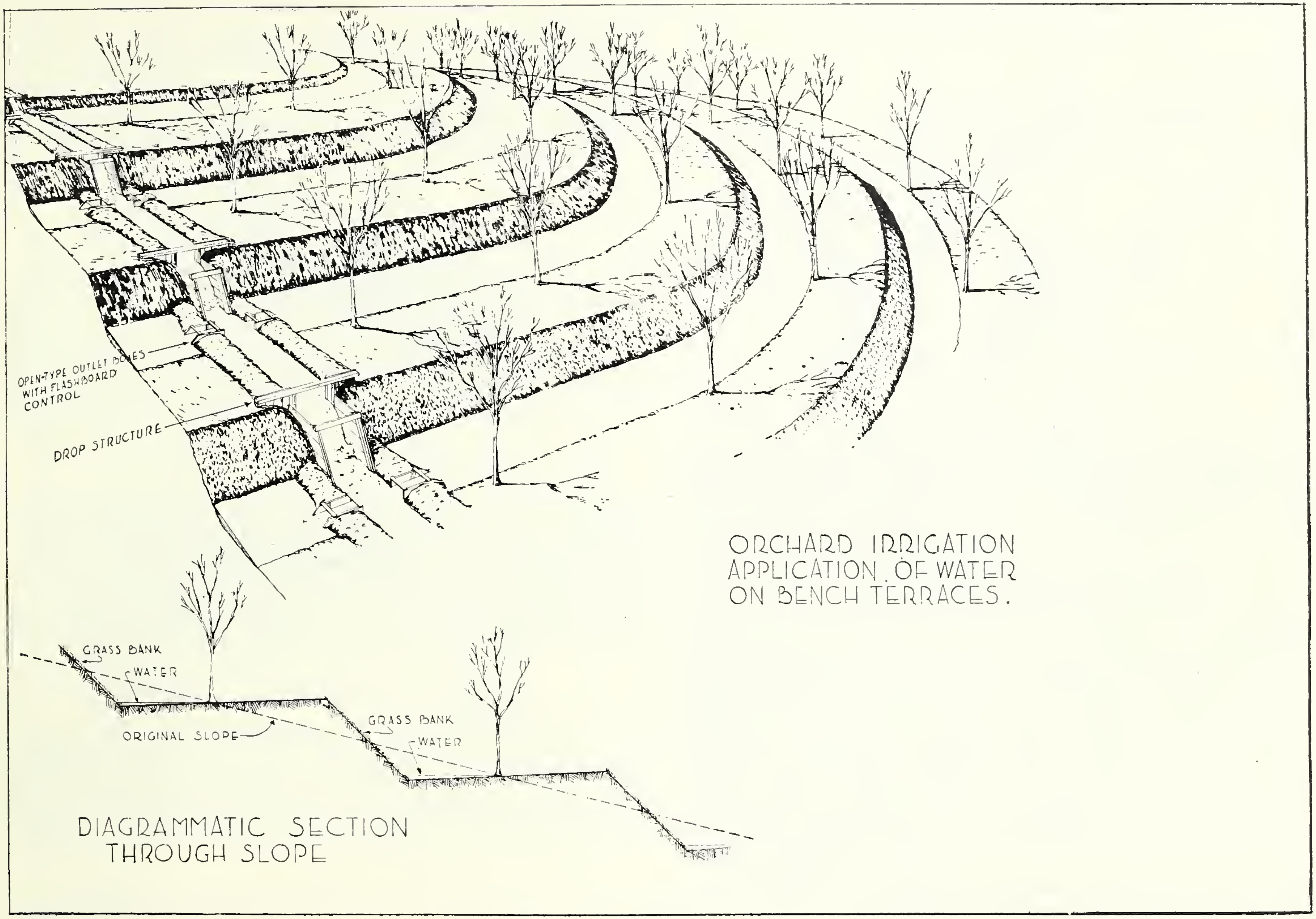
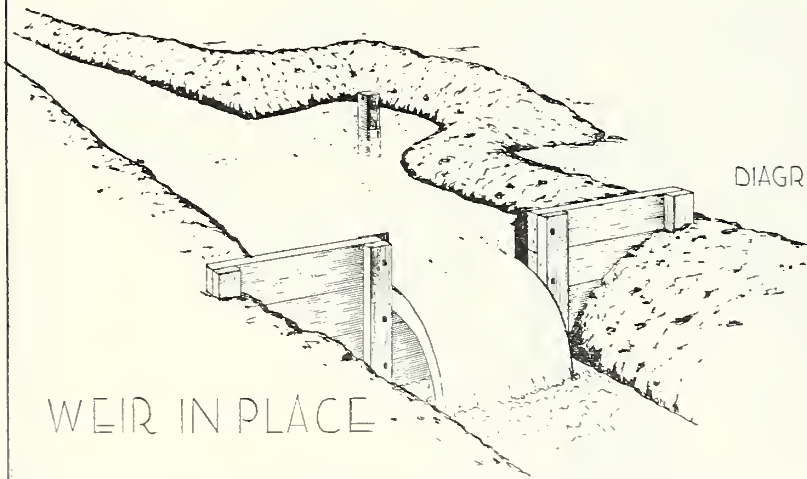

OPEN-TYPE OUTLET BOXES WITH FLASHBOARD CONTROL
DROP STRUCTURE
ORCHARD IRRIGATION APPLICATION OF WATER ON BENCH TERRACES.
GRASS BANK
WATER
ORIGINAL SLOPE
GRASS BANK
WATER
DIAGRAMMATIC SECTION THROUGH SLOPE

Figure 15.



WEIR IN PLACE

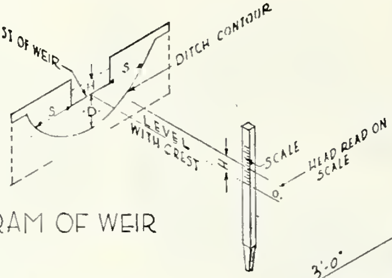
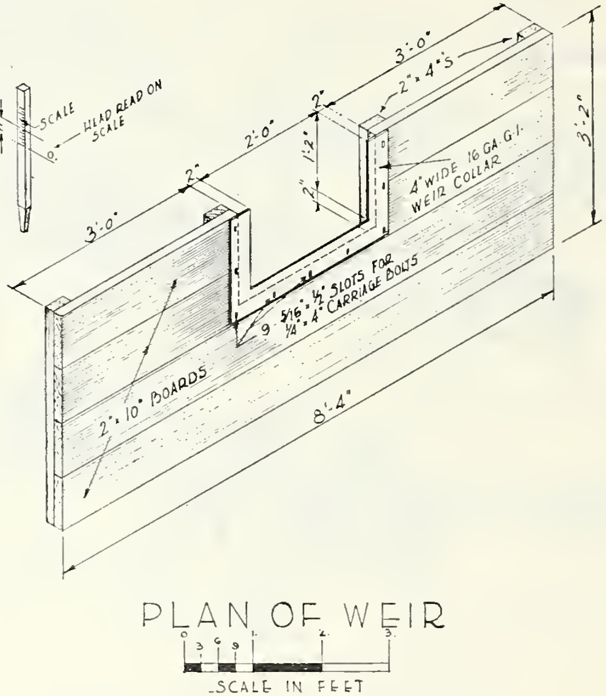


DIAGRAM OF WEIR



3'-0"
2"x4"S
2"
2'-0"
1'-2"
2"
2"
3'-0"
3'-2"
4" WIDE 16 GA. G.I. WEIR COLLAR
9 - 5/16" x 1/2" SLOTS FOR 1/4" x 4" CARRIAGE BOLTS
2" x 10" BOARDS
8'-4"
0
3
6
9
1.
2.
3.
SCALE IN FEET

PLAN OF WEIR

FLOW OVER RECTANGULAR CONTRACTED WEIR: 2'-0" CREST

HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C.F.S.	FLOW IN GALLONS PER MIN.	HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C.F.S.	FLOW IN GALLONS PER MIN.	HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C.F.S.	FLOW IN GALLONS PER MIN.
0.15	1 13/16	0.385	173	0.39	4 11/16	1.57	705	0.63	7 9/16	3.17	1,420
0.16	1 15/16	0.423	190	0.40	4 13/16	1.63	731	0.64	7 11/16	3.25	1,460
0.17	2 1/16	0.463	208	0.41	4 15/16	1.69	758	0.65	7 13/16	3.32	1,490
0.18	2 3/16	0.504	226	0.42	5 1/16	1.75	785	0.66	7 15/16	3.40	1,520
0.19	2 1/4	0.546	245	0.43	5 3/16	1.81	812	0.67	8 1/16	3.47	1,560
0.20	2 3/8	0.588	264	0.44	5 1/4	1.88	842	0.68	8 3/16	3.56	1,590
0.21	2 1/2	0.632	284	0.45	5 3/8	1.94	870	0.69	8 1/4	3.63	1,630
0.22	2 5/8	0.677	304	0.46	5 1/2	2.00	898	0.70	8 3/8	3.71	1,660
0.23	2 3/4	0.723	325	0.47	5 5/8	2.07	927	0.71	8 1/2	3.78	1,700
0.24	2 7/8	0.769	346	0.48	5 3/4	2.13	956	0.72	8 5/8	3.86	1,730
0.25	3	0.817	367	0.49	5 7/8	2.20	985	0.73	8 3/4	3.94	1,770
0.26	3 1/8	0.865	388	0.50	6	2.26	1,020	0.74	8 7/8	4.02	1,800
0.27	3 1/4	0.914	410	0.51	6 1/8	2.33	1,050	0.75	9	4.10	1,840
0.28	3 3/8	0.965	434	0.52	6 1/4	2.40	1,080	0.76	9 1/8	4.18	1,880
0.29	3 1/2	1.02	457	0.53	6 3/8	2.46	1,110	0.77	9 1/4	4.26	1,910
0.30	3 5/8	1.07	480	0.54	6 1/2	2.53	1,140	0.78	9 3/8	4.34	1,950
0.31	3 3/4	1.12	504	0.55	6 5/8	2.60	1,170	0.79	9 1/2	4.42	1,980
0.32	3 13/16	1.18	528	0.56	6 3/4	2.67	1,200	0.80	9 5/8	4.51	2,020
0.33	3 15/16	1.23	552	0.57	6 13/16	2.74	1,230	0.81	9 3/4	4.59	2,060
0.34	4 1/16	1.28	576	0.58	6 15/16	2.81	1,260	0.82	9 13/16	4.67	2,100
0.35	4 3/16	1.34	601	0.59	7 1/16	2.88	1,290	0.83	9 15/16	4.75	2,130
0.36	4 5/16	1.40	627	0.60	7 3/16	2.96	1,330	0.84	10 1/16	4.84	2,170
0.37	4 7/16	1.45	653	0.61	7 5/16	3.03	1,360				
0.38	4 9/16	1.51	679	0.62	7 7/16	3.10	1,390				

C.F.S. MAY BE READ AS ACRE INCHES PER HOUR.

Figure 16.

lateral. It should be located in the center of the channel with the upper floor set level. Dirt should be thoroughly tamped around it or undercutting will result.

To measure the quantity of water flowing through the flume, read the depth of water on the rule or scale in decimals of a foot or in inches. Then from the table in figure 17 read the flow in cubic feet per second. To find the flow in gallons per minute multiply cubic feet per second by 448.83.

DIVISION BOX

In addition to a measuring device at the point where the water flows onto the farm from the main canal or lateral, or at other points where water is to be turned into ditches running in several directions, a division box may be installed. A three-way division box is shown in figure 18. The type shown here is of creosoted lumber and is not as permanent as one built of masonry, but it has the advantage of being more or less easy to move. Wet earth must be tightly compacted around the walls of such structures or undercutting is sure to result. The location of a division box is shown on figure 1 in the upper left corner.

DROP STRUCTURES

When a ditch is dug on a steep grade the water must somehow be kept from flowing so fast that it erodes the bed or banks. This may be done by installing drop structures. A wood drop structure is shown in figure 18 and a concrete drop in figure 19. The wooden drop structure is built of creosoted lumber and is not as permanent as one built of masonry, but has the advantage of being more or less easy to move. Wet earth must be tightly compacted around the wall of such structures or undercutting is sure to result. Drop structures are shown in figure 1, located along the left side of the layout.

INVERTED SIPHON AND FLUME

A method of carrying irrigation water across gullies and under lanes or other obstacles is shown in figure 20. Water is carried across deep gullies or other deep depressions by elevated flumes. Water is carried underneath roadways or other such obstacles by means of an "inverted siphon." This inverted siphon is generally made of concrete pipe for small flows. The larger siphons are generally made of concrete poured in place. The rate of flow through the siphon will depend on the difference in elevation between the inlet and the outlet. Figure 20 shows such a structure.

Emergency Drop Structures, Checks, and Turn-outs

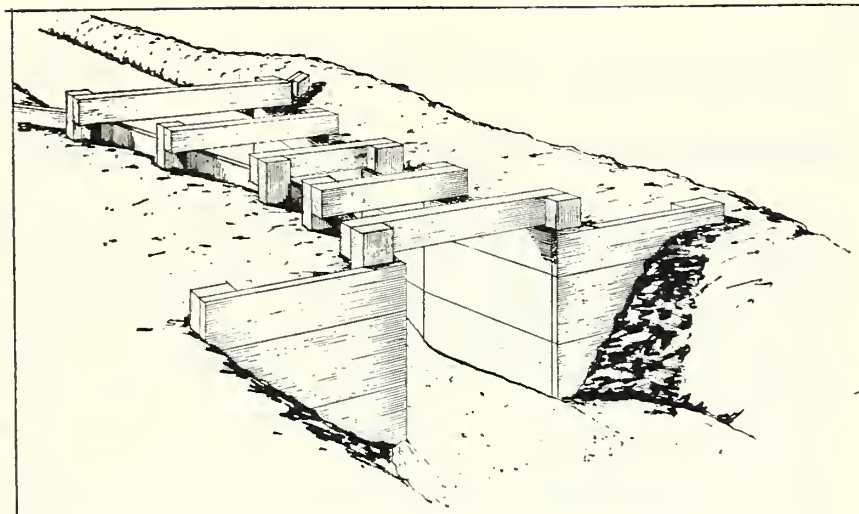
Irrigators have found it helpful to use gunny sacks for building emergency structures. By filling sacks with sand or coarse sandy soil, drops of all sizes may be made, as well as small checks (fig. 21). Emergency repairs to canal or lateral banks can be made with sandbags without interrupting the flow.

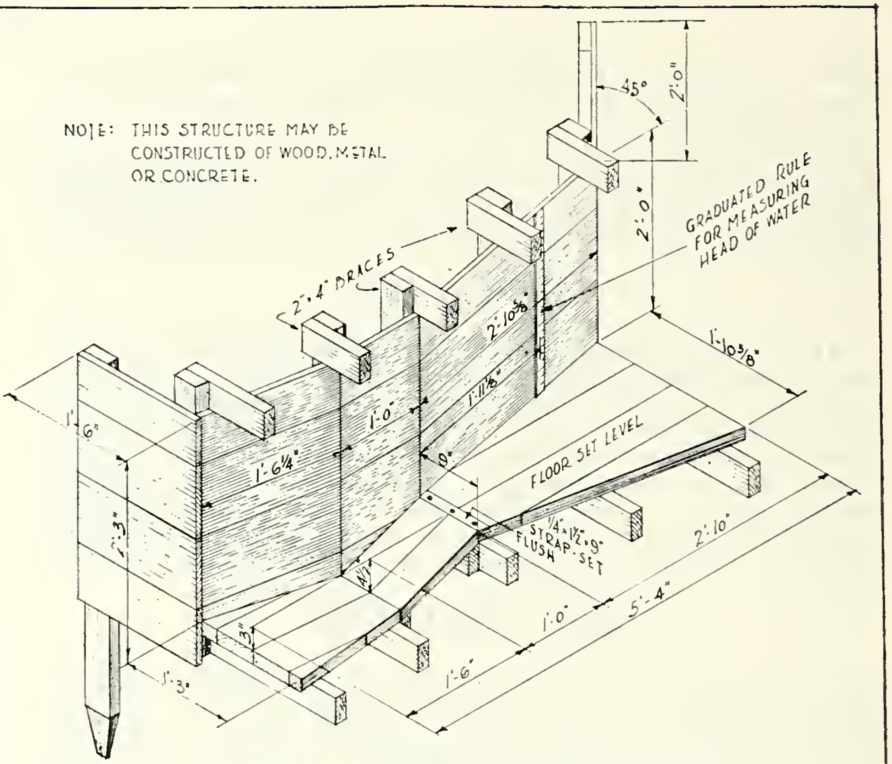
A convenient and fairly permanent canal turn-out can be made with gunny sacking as shown in figure 21. The following steps will assure good results:

1. Wet the square of sack material and spread on the ditch bank as shown at *A*, *B*, *C*, *D*.
2. Using the point of the irrigation shovel, starting at *E* push the edge of the sacking firmly into the mud, as shown by dotted line *E*, *F*, *G*.
3. Raise the edge of the sacking *CD* in the left hand and with the shovel remove dirt from the ditch bank at *H*.
4. Pat the sacking at *H* until sufficient flow passes over it. The volume of flow may be controlled by raising and lowering the sacking at *H*, either by using a shovelful of dirt or a folded piece of sacking.
5. The edge of the sacking *CD* is put in position as shown to prevent erosion of the ditch bank.

IRRIGATION EQUIPMENT

Getting land ready for irrigation and keeping it in shape calls for special equipment not generally found on dry-land farms, such as leveler floats, ditcher, and so on. Heavy-duty equipment, not shown here, is needed for clearing, grading, and leveling land for irrigation, but there are many types of lighter equipment useful in finishing the process of preparing the land and keeping it level. After the land surface has been smoothed by leveling, care must be exercised even in plowing operations not to leave ridges and dead furrows which are a hindrance to proper water distribution. Use of the two-way plow shown in figure 22 will avoid dead furrows and ridges.





NOTE: THIS STRUCTURE MAY BE CONSTRUCTED OF WOOD, METAL OR CONCRETE.

PARSHALL FLUME: 9" THROAT
SIDE REMOVED TO SHOW CONSTRUCTION

0 3 6 9 1 2
SCALE

"FREE-FLOW" THRU A PARSHALL MEASURING FLUME: 9" THROAT

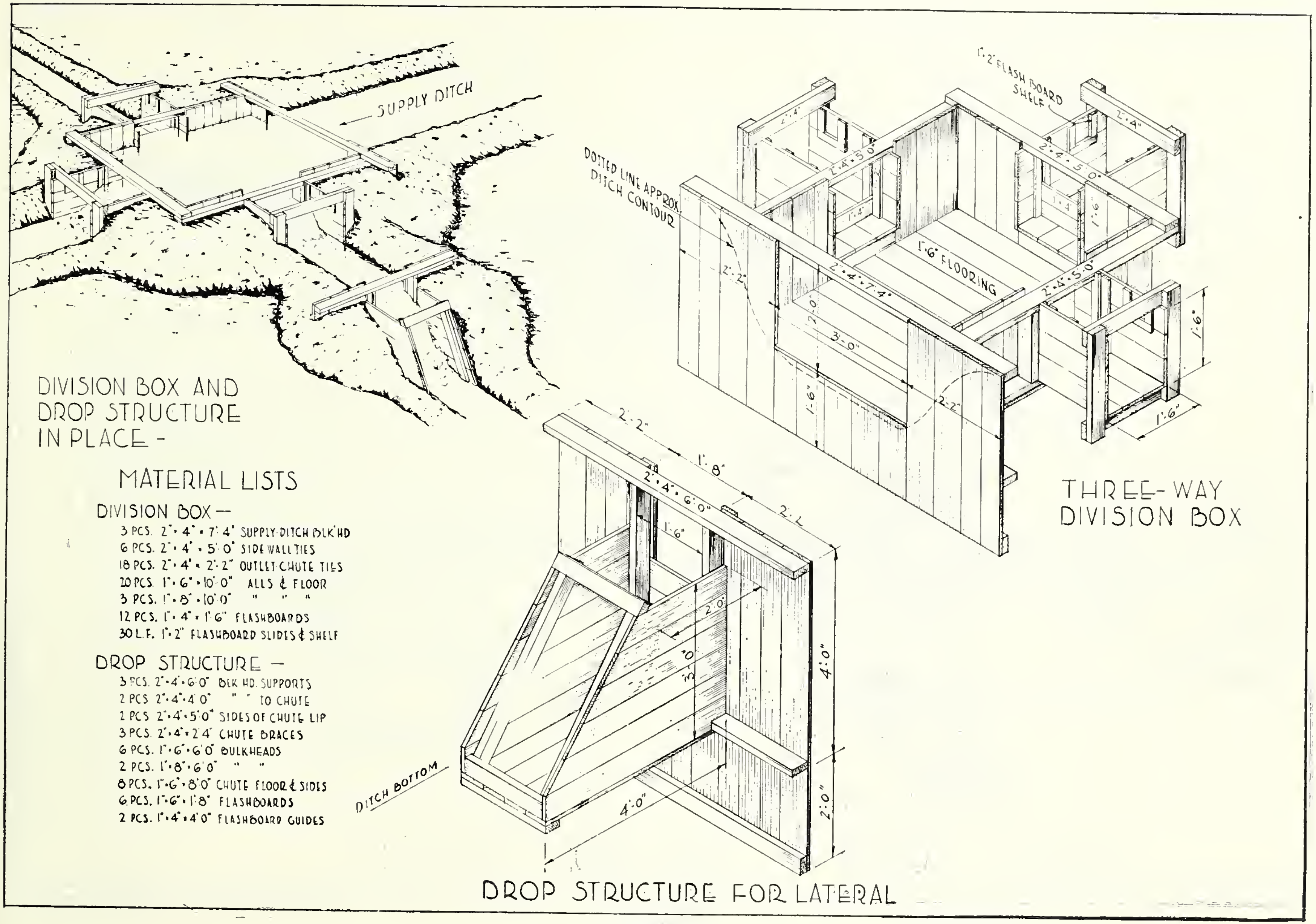
HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C·F·S·	HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C·F·S·	HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C·F·S·	HEAD IN FEET	HEAD IN INCHES APPROX.	FLOW IN C·F·S·
0.10	1 3/16	0.09	0.43	5 3/16	0.84	0.76	9 1/8	2.02	1.09	13 1/16	3.50
0.11	1 5/16	0.10	0.44	5 1/4	0.87	0.77	9 1/4	2.06	1.10	13 3/16	3.55
0.12	1 7/16	0.12	0.45	5 3/8	0.90	0.78	9 3/8	2.10	1.11	13 5/16	3.60
0.13	1 9/16	0.14	0.46	5 1/2	0.94	0.79	9 1/2	2.14	1.12	13 7/16	3.65
0.14	1 11/16	0.15	0.47	5 5/8	0.97	0.80	9 5/8	2.18	1.13	13 9/16	3.70
0.15	1 13/16	0.17	0.48	5 3/4	1.00	0.81	9 3/4	2.22	1.14	13 11/16	3.75
0.16	1 15/16	0.19	0.49	5 7/8	1.03	0.82	9 13/16	2.27	1.15	13 13/16	3.80
0.17	2 1/16	0.20	0.50	6	1.06	0.83	9 15/16	2.31	1.16	13 15/16	3.85
0.18	2 3/16	0.22	0.51	6 1/8	1.10	0.84	10 1/16	2.35	1.17	14 1/16	3.90
0.19	2 1/4	0.24	0.52	6 1/4	1.13	0.85	10 3/16	2.39	1.18	14 3/16	3.95
0.20	2 3/8	0.26	0.53	6 3/8	1.16	0.86	10 5/16	2.44	1.19	14 1/4	4.01
0.21	2 1/2	0.28	0.54	6 1/2	1.20	0.87	10 7/16	2.48	1.20	14 3/8	4.06
0.22	2 5/8	0.30	0.55	6 5/8	1.23	0.88	10 9/16	2.52	1.21	14 1/2	4.11
0.23	2 3/4	0.32	0.56	6 3/4	1.26	0.89	10 11/16	2.57	1.22	14 5/8	4.16
0.24	2 7/8	0.35	0.57	6 13/16	1.30	0.90	10 13/16	2.61	1.23	14 3/4	4.22
0.25	3	0.37	0.58	6 15/16	1.33	0.91	10 15/16	2.66	1.24	14 7/8	4.27
0.26	3 1/8	0.39	0.59	7 1/16	1.37	0.92	11 1/16	2.70	1.25	15	4.32
0.27	3 1/4	0.41	0.60	7 3/16	1.40	0.93	11 3/16	2.75	1.26	15 1/8	4.37
0.28	3 3/8	0.44	0.61	7 5/16	1.44	0.94	11 1/4	2.79	1.27	15 1/4	4.43
0.29	3 1/2	0.46	0.62	7 7/16	1.48	0.95	11 3/8	2.84	1.28	15 3/8	4.48
0.30	3 5/8	0.49	0.63	7 9/16	1.51	0.96	11 1/2	2.88	1.29	15 1/2	4.53
0.31	3 3/4	0.51	0.64	7 11/16	1.55	0.97	11 5/8	2.93	1.30	15 5/8	4.59
0.32	3 13/16	0.54	0.65	7 13/16	1.59	0.98	11 3/4	2.98	1.31	15 3/4	4.64
0.33	3 15/16	0.56	0.66	7 15/16	1.63	0.99	11 7/8	3.02	1.32	15 13/16	4.69
0.34	4 1/16	0.59	0.67	8 1/16	1.66	1.00	12	3.07	1.33	15 15/16	4.75
0.35	4 3/16	0.62	0.68	8 3/16	1.70	1.01	12 1/8	3.12	1.34	16 1/16	4.80
0.36	4 5/16	0.64	0.69	8 1/4	1.74	1.02	12 1/4	3.17	1.35	16 3/16	4.86
0.37	4 7/16	0.67	0.70	8 3/8	1.78	1.03	12 3/8	3.21	1.36	16 5/16	4.92
0.38	4 9/16	0.70	0.71	8 1/2	1.82	1.04	12 1/2	3.26	1.37	16 7/16	4.97
0.39	4 11/16	0.73	0.72	8 5/8	1.86	1.05	12 5/8	3.31	1.38	16 9/16	5.03
0.40	4 13/16	0.76	0.73	8 3/4	1.90	1.06	12 3/4	3.36	1.39	16 11/16	5.08
0.41	4 15/16	0.78	0.74	8 7/8	1.94	1.07	12 13/16	3.40	C·F·S· MAY BE READ AS ACRE-INCHES PER HOUR		
0.42	5 1/16	0.81	0.75	9.	1.98	1.08	12 15/16	3.45			

MATERIAL LIST

FLOOR: 2 PCS. 2"·6"·8'-0"
1 PC. 2"·6"·6'-0"
SIDE WALLS. 4 PCS. 1"·10"·8'-0"
2 PCS. 1"·6"·8'-0"
1 PC. 1"·4"·6'-0"
WINGS. 3 PCS. 1"·10"·8'-0"
1 PC. 1"·6"·8'-0"
BRACES: 8 PCS. 2"·4"·10'-0"
STRAP-IRON CREST PC. ¼"·1½"×9"
GRADUATED RULE · 24" LONG - ENAMELED STEEL PREFERABLE

NOTE: GAL'S. PER MIN. = C·F·S × 448.83

FIGURE 17.



MATERIAL LISTS

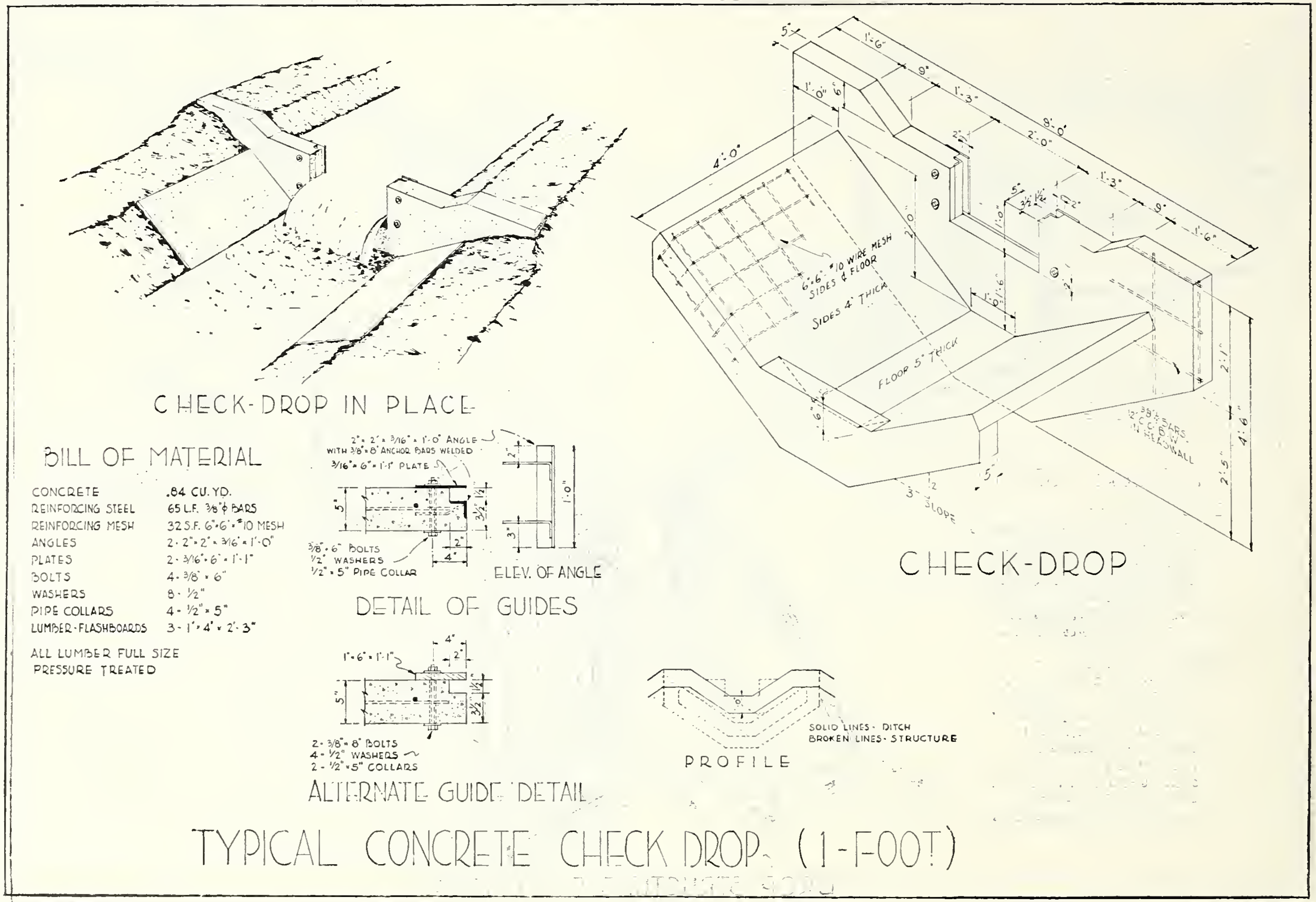
DIVISION BOX —

- 3 PCS. 2"•4"•7'4" SUPPLY-DITCH BLK'HD
- 6 PCS. 2"•4"•5'0" SIDE WALL TIES
- 18 PCS. 2"•4"•2'2" OUTLET CHUTE TIES
- 20 PCS. 1"•6"•10'0" ALLS & FLOOR
- 3 PCS. 1"•8"•10'0" " " "
- 12 PCS. 1"•4"•1'6" FLASHBOARDS
- 30 L.F. 1"•2" FLASHBOARD SLIDES & SHELF

DROP STRUCTURE —

- 3 PCS. 2"•4"•6'0" BLK HD. SUPPORTS
- 2 PCS 2"•4"•4'0" " " TO CHUTE
- 2 PCS 2"•4"•5'0" SIDES OF CHUTE LIP
- 3 PCS. 2"•4"•2'4" CHUTE BRACES
- 6 PCS. 1"•6"•6'0" BULKHEADS
- 2 PCS. 1"•8"•6'0" " "
- 8 PCS. 1"•6"•8'0" CHUTE FLOOR & SIDES
- 6 PCS. 1"•6"•1'8" FLASHBOARDS
- 2 PCS. 1"•4"•4'0" FLASHBOARD GUIDES

FIGURE 18.

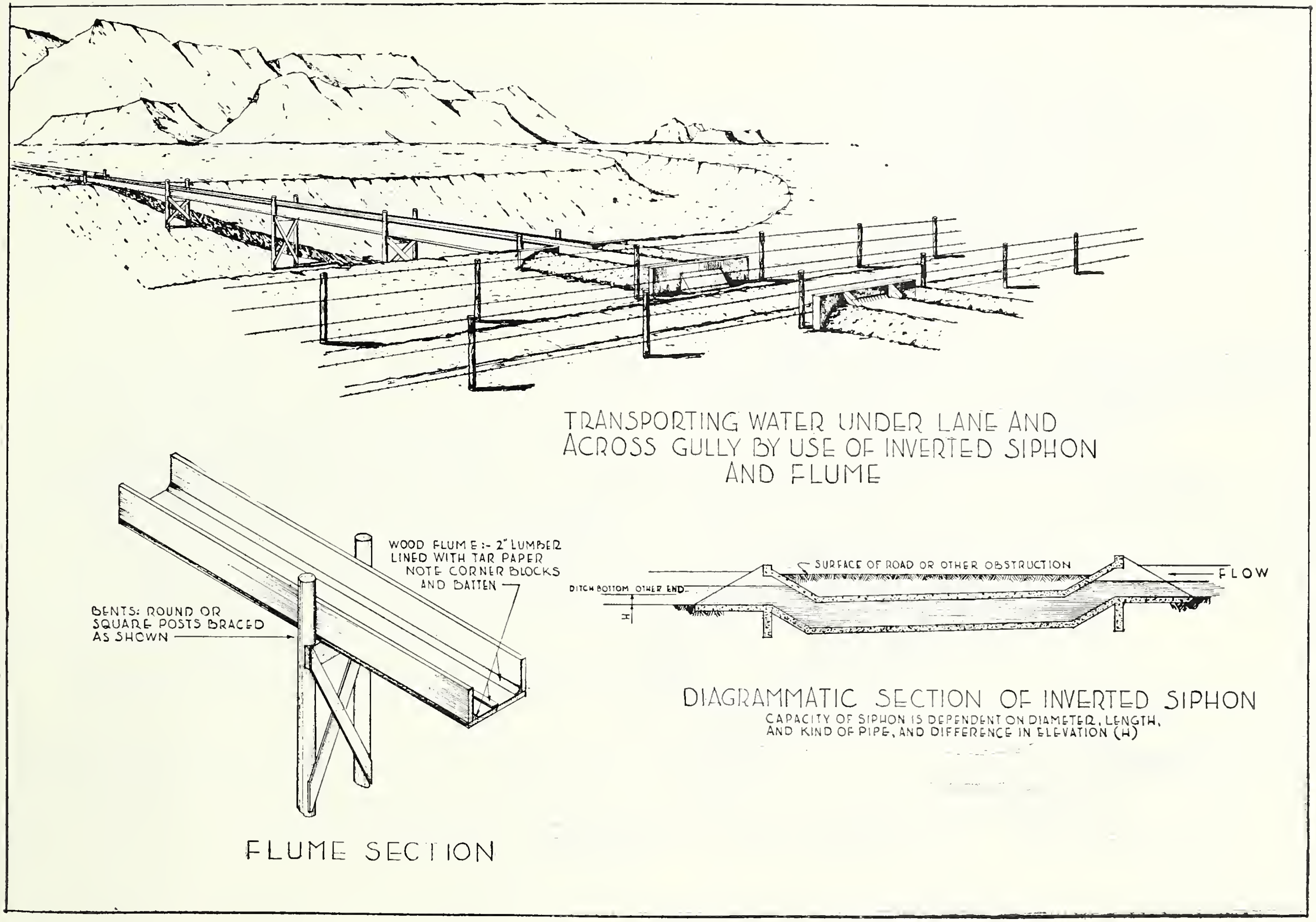


BILL OF MATERIAL

CONCRETE	.84 CU. YD.
REINFORCING STEEL	65 L.F. 3/8"φ BARS
REINFORCING MESH	32 S.F. 6"×6"×#10 MESH
ANGLES	2-2"×2"×3/16"×1'-0"
PLATES	2-3/16"×6"×1'-1"
BOLTS	4-3/8"×6"
WASHERS	8-½"
PIPE COLLARS	4-½"×5"
LUMBER-FLASHBOARDS	3-1"×4"×2'-3"

ALL LUMBER FULL SIZE
PRESSURE TREATED

FIGURE 19.



TRANSPORTING WATER UNDER LANE AND ACROSS GULLY BY USE OF INVERTED SIPHON AND FLUME

FLUME SECTION

WOOD FLUME:- 2" LUMBER LINED WITH TAR PAPER NOTE CORNER BLOCKS AND BATTEN
BENTS: ROUND OR SQUARE POSTS BRACED AS SHOWN

DIAGRAMMATIC SECTION OF INVERTED SIPHON

CAPACITY OF SIPHON IS DEPENDENT ON DIAMETER, LENGTH, AND KIND OF PIPE, AND DIFFERENCE IN ELEVATION (H)

SURFACE OF ROAD OR OTHER OBSTRUCTION
FLOW
DITCH BOTTOM OTHER END
H

FIGURE 20.

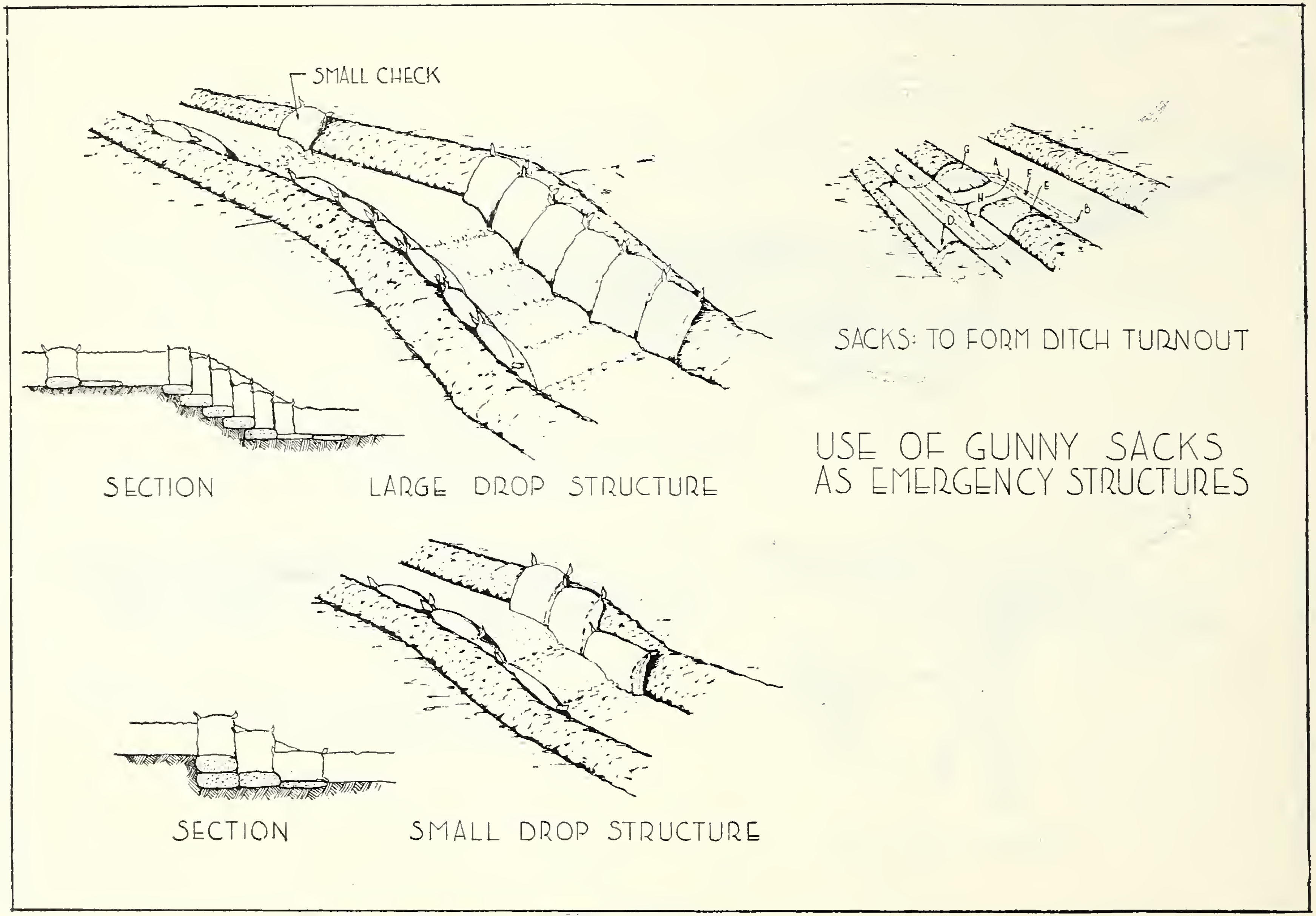

SMALL CHECK
SECTION
LARGE DROP STRUCTURE
A
B
C
D
E
F
G
H
SACKS: TO FORM DITCH TURNOUT
USE OF GUNNY SACKS
AS EMERGENCY STRUCTURES
SECTION
SMALL DROP STRUCTURE

FIGURE 21.

Other field operations such as disking, listing, and potato digging tend to roughen the land surfaces making water application difficult. To correct these irregularities the irrigation float is used several times each season. For filng holes or placing dirt in the ditchbank the buck scraper or the cutting float (fig. 23) is a convenient implement.

Other pieces of equipment that may be found on most irrigated farms are the ditcher, the corrugator, and the border drag. Much of this equipment can be made at home, and construction details and materials needed are listed with the drawings. Many efficient commercially made implements are readily available from dealers in most irrigated communities.

PLOWS

Correct plowing practices are important if field surfaces are to be kept from becoming uneven and difficult to irrigate. On dry-land farms it is common practice to use ordinary plows and to plow fields in lands, as shown in the left-hand corner of figure 22. Soil is moved outward from the dead furrow each season, resulting in development of high and low areas.

Experienced irrigation farmers prefer a two-way plow, which it is possible to use without producing a dead furrow and without leaving an uneven surface, as shown in the right-hand corner of figure 22. In using the two-way plow one plow is lowered for operation and one is raised as shown in the lower left corner of figure 22. When once across the field, the other plow is lowered and the first plow raised for the return trip. The irrigation leveler float should be used occasionally to remove minor irregularities.

BUCK SCRAPER AND CUTTING FLOAT

The buck scraper shown in figure 23 is a convenient and economical implement in land-leveling operations. It is particularly useful in moving earth from high spots and filling low spots. When drawn by a team of horses, it may be used while water is being applied to borders. After the space between border dikes has been leveled with the float, water may be turned in and the leveling process finished as the low and high spots are revealed. The cutting float (fig. 23) is used in somewhat the same manner but is drawn by tractor power and is not adapted to wet leveling.

IRRIGATION LEVELER FLOAT

The irrigation leveler float shown in figure 24 is used to produce a uniform, smooth land surface, free from minor irregularities, over which water may be evenly distributed. In order to function properly the float should be not less than 18 feet long. It should have at least one adjustable cross member to allow for variable soil conditions. The use of divided rollers makes turning easier and reduces draft. Many types of floats are available, both commercial and home-made. The irregularities produced by farming operations make the use of the float desirable each season on all irrigated fields.

DITCHER

Canals and large ditches are made with special ditching equipment. But smaller ditches and field laterals can be made by ditchers such as that shown in figure 25. This ditcher is easily and cheaply made at home. Its design and operation are self-explanatory.

ADJUSTABLE CROWDER

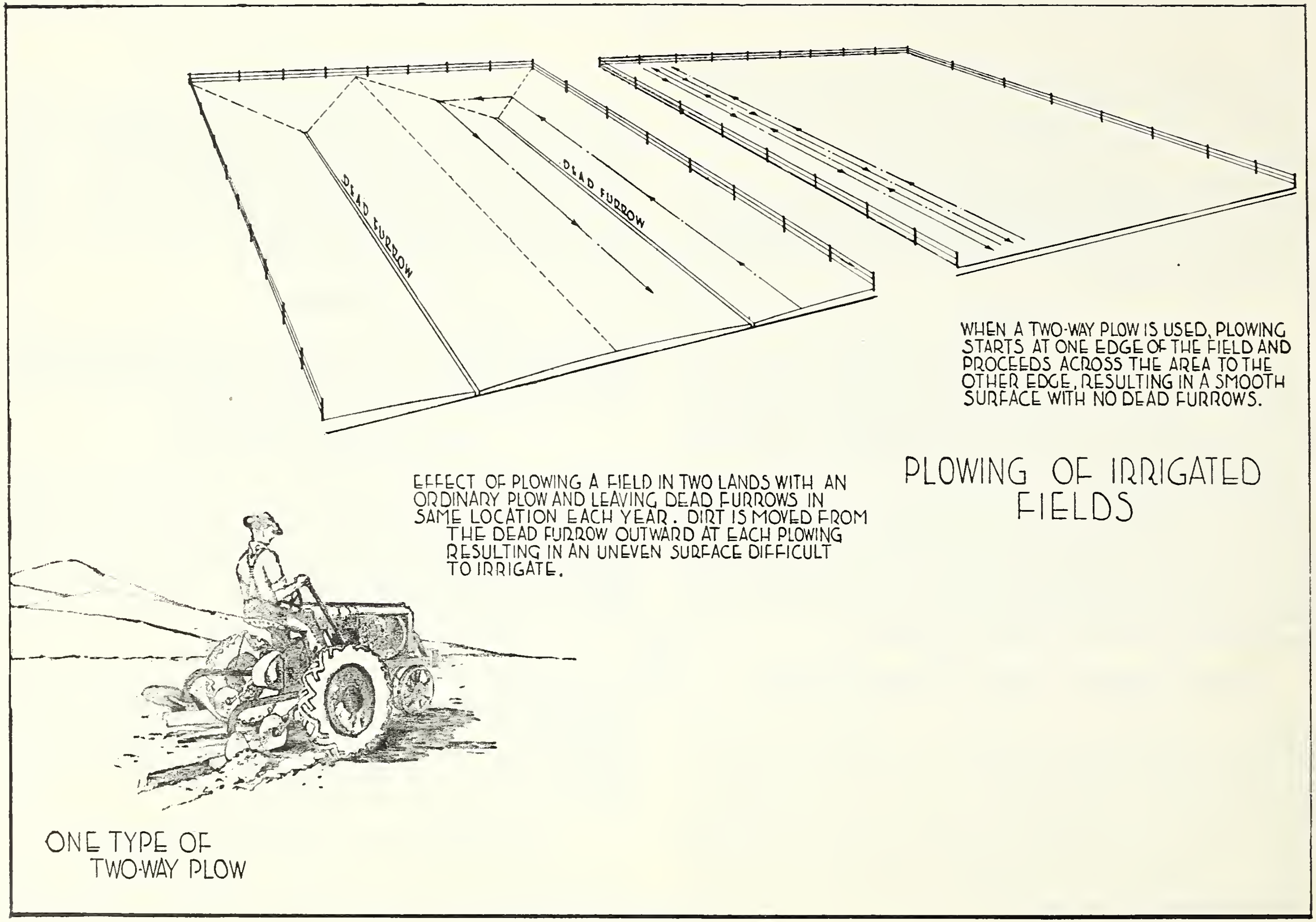
The adjustable crowder (fig. 26) is essentially a one-way ditcher, adapted to making various-width ditches by adjusting the spreader board between the runner and the crowder. Several furrows are first plowed to loosen the dirt. Then the crowder with the crowder board leaning upward and outward crowds the dirt to one side to form the ditchbank. This operation is then repeated in the opposite direction to form the bank on the other side.

THE CORRUGATOR

The corrugator (fig. 26) is used to make small furrows or corrugations for conducting irrigation water over the ground surface. Corrugations are particularly adapted to watering grain or hay crops on irregular fields or for new fields which have not been thoroughly leveled and floated. The runners are commonly made of 4-inch by 6-inch material spaced 30 inches apart. This spacing may vary, however, depending on the soil and slope of the land.

TORPEDO-TYPE FURROW OPENER

The torpedo-type furrow opener is used on flat land and porous soil. Its operation and construction are shown in figure 27. The disk at the



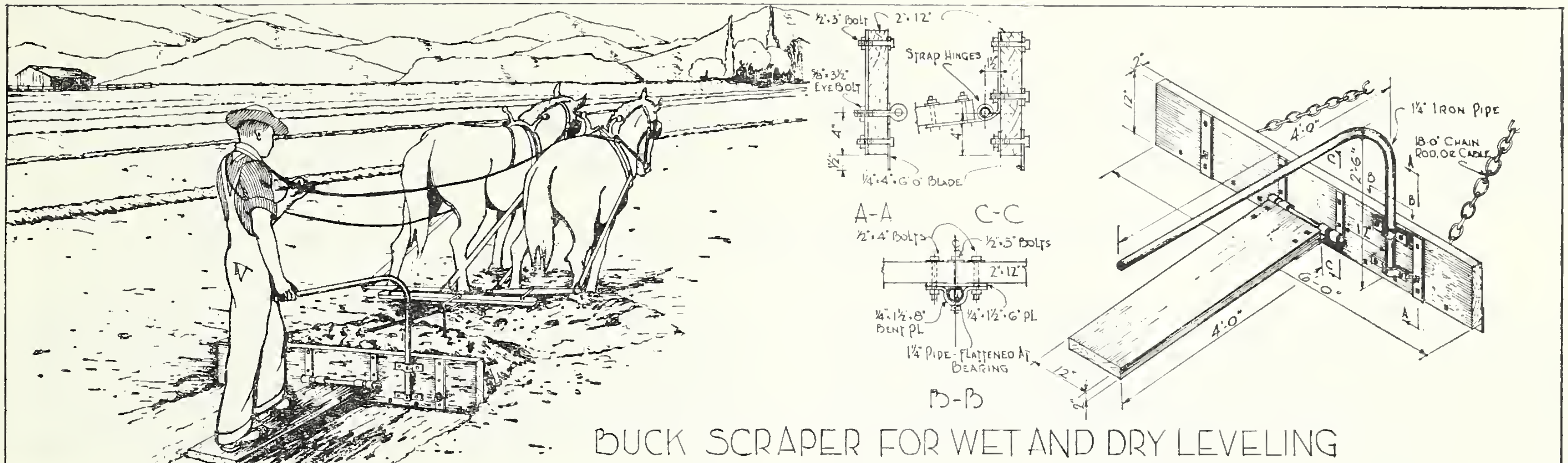
PLOWING OF IRRIGATED FIELDS

EFFECT OF PLOWING A FIELD IN TWO LANDS WITH AN ORDINARY PLOW AND LEAVING DEAD FURROWS IN SAME LOCATION EACH YEAR. DIRT IS MOVED FROM THE DEAD FURROW OUTWARD AT EACH PLOWING RESULTING IN AN UNEVEN SURFACE DIFFICULT TO IRRIGATE.

WHEN A TWO-WAY PLOW IS USED, PLOWING STARTS AT ONE EDGE OF THE FIELD AND PROCEEDS ACROSS THE AREA TO THE OTHER EDGE, RESULTING IN A SMOOTH SURFACE WITH NO DEAD FURROWS.

ONE TYPE OF TWO-WAY PLOW

Figure 22.



BILL OF MATERIAL-"BUCK SCRAPER"

1 - 2"·12"·6'-0" - BUCK BOARD
1 - 2"·12"×4'-0" - TRAILER BOARD
1 - 1¼"×6'-6" - IRON-PIPE HANDLE
1 - ¼"×4"·6'-0" - STRAP-IRON CUTTING EDGE
4 - ¼"·1½"·12" - STRAP-IRON HINGES
2 - ¼"·2"×12" - STRAP IRON
2 - ¼"×1½"×6" - STRAP IRON--- PIPE CLAMP
2 - ¼"×1½"×8" - BENT STRAP IRON " "
1 - ⅝"×18" - BOLT FOR HINGE
2 - ⅝"×3½" - EYEBOLTS
2 - ½"×5" - CARRIAGE BOLTS
4 - ½"×4" - " "
22 - ½"×3" " "
2 - ⅝" WASHERS
28 - ½" "
18'-0" CHAIN-ROD-OR CABLE HITCH.

BILL OF MATERIAL-"CUTTING FLOAT"

1 - 3"·12"·20'-0" BUCK BOARD
3 - 2"·8"×3'-0" FOR TRAILER BOARD
1 - 1¼"×6'-0" - IRON-PIPE HANDLE
1 - ⅜"·6"·20'-0" STRAP-IRON CUTTING EDGE
4 - ¼"·1½"·12" - STRAP-IRON HINGES
2 - ¼"·3"×2'-0" - STRAP-IRON CLEATS
3 - ¼"×3"×3" - FLAT ASHERS
4 - ¼"×1½"×6" - STRAP-IRON - PIPE CLAMP
2 - ¼"×1½"×8" " " " "
1 - ¾"×2'6" BOLT FOR HINGE
3 - ¾"×5" - EYEBOLTS
2 - ½"·6" - CARRIAGE BOLTS
4 - ½"·5" " "
14 - ½"·3" " "
8 - ½"·4" " "
22 - ½" WASHERS
1 - ⅝"φ ×6'-0" ROD FOR HITCH
2 - 9'-0" CHAINS, CABLE, OR RODS FOR HITCH
1 - 4" RING FOR HITCH

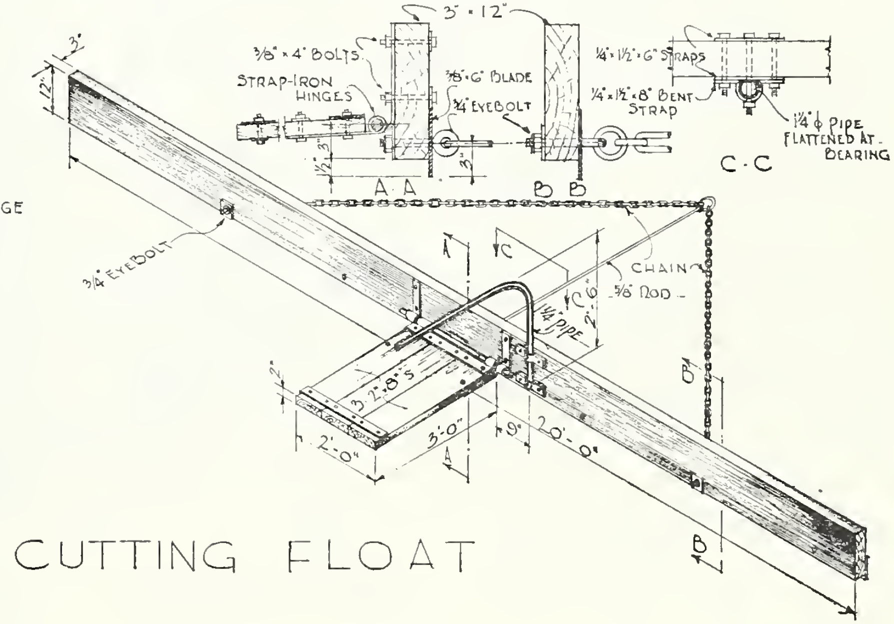


Figure 23.

head of the torpedo opens the furrow and the weight of the concrete barrel packs down the earth as the torpedo is dragged through the furrow. By driving at ordinary speeds, good alignment can be accomplished. The smooth-packed furrow allows irrigation water to run at a uniform rate to the lower end of the field with a minimum of deep-percolation losses.

BORDER DRAG

The border drag shown in figure 28 is used to build border dikes like those shown in figure 10. There are other types of implements used for building the border dikes, depending on the size of the borders, the slope of the land, etc. The type shown in figure 28 is a home-made wooden drag.

PUMPING IRRIGATION WATER FROM WELLS, LAKES, OR STREAMS

Several illustrations which follow show pump installations for raising water from wells, lakes, or streams. In order that the proper pump and power plant may be selected it is necessary to have information regarding the rate of flow required, the distance the water must be lifted, and other factors such as the friction head in the pipe and the friction loss in elbows, foot valves, etc. Unless the proper pump is selected, the efficiency may be low and the cost of operation higher than necessary.

Many types of pumps and power plants are now available. There is a marked tendency, however, to use high-speed Diesel engines or electricity on the greater lifts.

TURBINE AND PROPELLER-TYPE IRRIGATION PUMPS

The turbine-type irrigation pump (fig. 29) is adapted to lifting water from wells of various diameters and through various heads, from a few feet to several hundred feet. The characteristics of the pump are determined largely by the design of the bowl assembly and the speed of the impeller shaft.

In order to determine the type of pump and design of bowl assembly required for the best efficiency under given conditions, the manufacturers should have the following information:

1. The discharge of the well at various stages of draw-down. This is determined by a pump test of the well.
2. The diameter of the well casing.
3. The type of power to be used for driving the pump.

Where three-phase electrical energy is available, the direct-connected motor drive may be used. Other types of drives for the turbine pump are shown.

The propeller type pump is adapted to lifting large volumes of water through low heads. In irrigation practices it is used to deliver water from a stream or lake to a canal at higher level or from a low-level canal to one at a higher level. The same types of drives as shown for the turbine are adapted to the propeller pump. In order to determine the type of pump required for the best efficiency under given conditions, the manufacturers should be given the following information:

1. The discharge required in gallons per minute or cubic feet per second.
2. The total head or lift in feet.
3. The type of power available.

INSTALLATION OF A HORIZONTAL CENTRIFUGAL PUMP

The horizontal centrifugal pump (fig. 30) is well adapted to pumping from streams or lakes or from one canal to another. The characteristics of this type of pump are determined largely by the design and speed of the impeller. The manufacturers should have the following information in order to furnish a pump which will give the best efficiency under given conditions.

1. The quantity of water to be derived in gallons per minute or cubic feet per second.
2. The total head, or lift, in feet.
3. The type of power available and the probable speed at which the pump will operate.

The total lift, or head, includes not only the actual vertical distance in feet to which water will be lifted as *A* plus *B* in figure 30, but also the friction head in the pipe and pipe fittings.

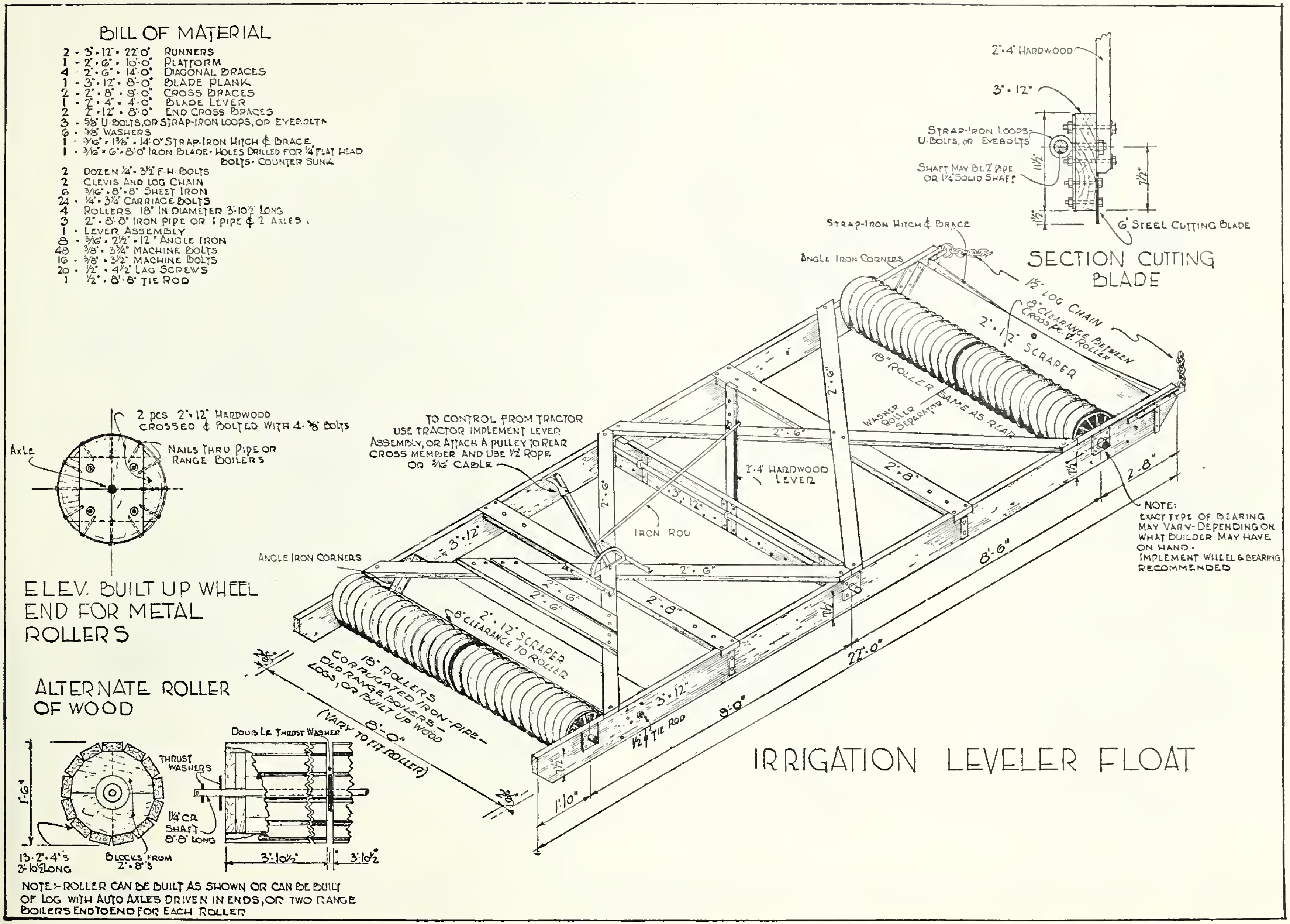
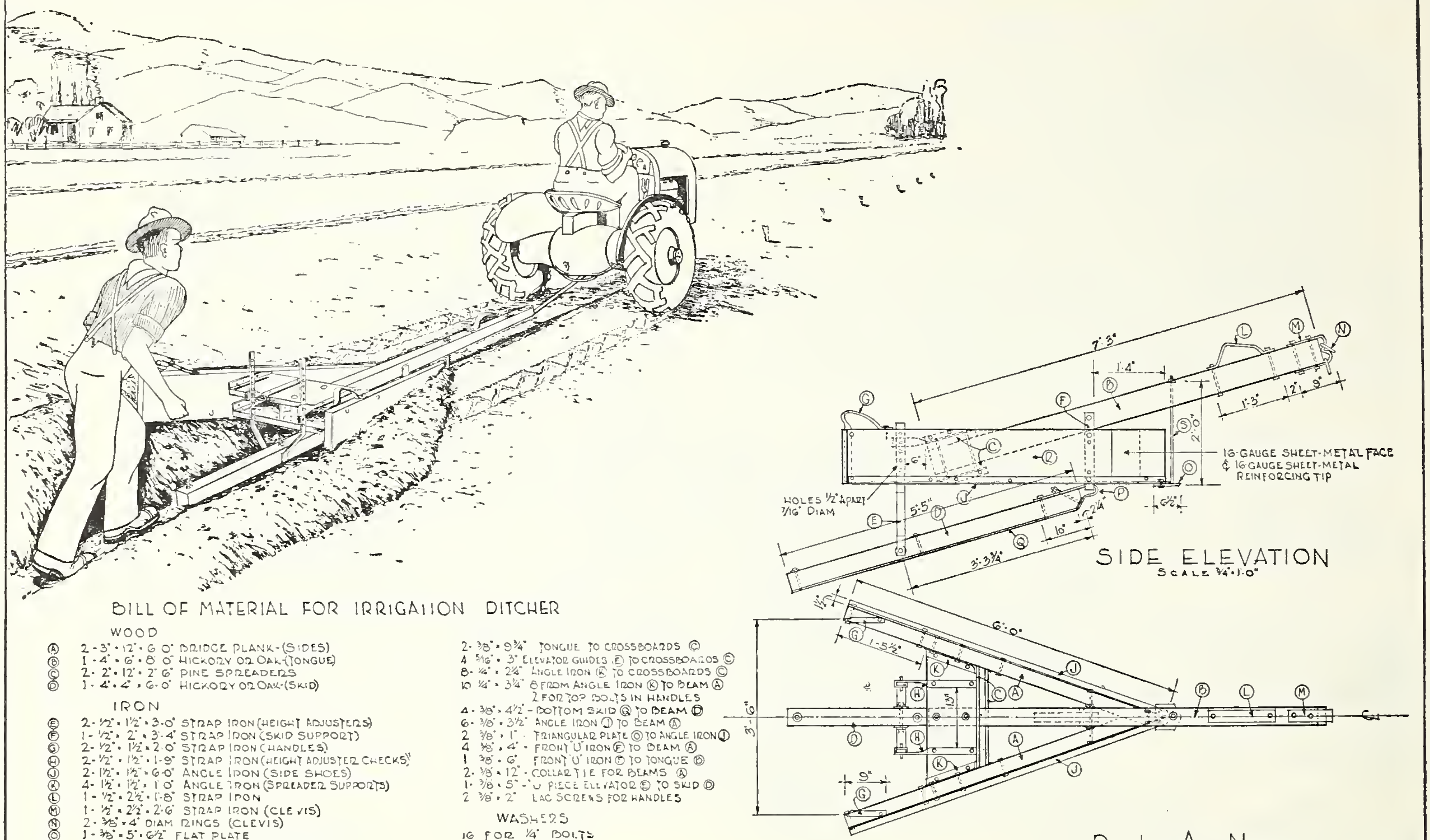

BILL OF MATERIAL
2 - 3" • 12" • 22'-0" RUNNERS
1 - 2" • 6" • 10'-0" PLATFORM
4 - 2" • 6" • 14'-0" DIAGONAL BRACES
1 - 3" • 12" • 8'-0" BLADE PLANK
2 - 2" • 8" • 9'-0" CROSS BRACES
1 - 2" • 4" • 4'-0" BLADE LEVER
2 2" • 12" • 8'-0" END CROSS BRACES
3 - 5/8" U-BOLTS, OR STRAP-IRON LOOPS, OR EYEBOLTS
6 - 5/8" WASHERS
1 - 3/16" • 1 5/8" • 14'-0" STRAP-IRON HITCH & BRACE
1 - 3/16" • 6" • 8'-0" IRON BLADE - HOLES DRILLED FOR 1/4" FLAT HEAD BOLTS - COUNTER SUNK
2 DOZEN 1/4" • 3 1/2" F.H. BOLTS
2 CLEVIS AND LOG CHAIN
6 3/16" • 8" • 8" SHEET IRON
24 - 1/4" • 3 1/4" CARRIAGE BOLTS
4 ROLLERS 18" IN DIAMETER 3'-10 1/2" LONG
3 2" • 8'-8" IRON PIPE OR 1 PIPE & 2 AXLES
1 - LEVER ASSEMBLY
8 - 3/16" • 2 1/2" • 12" ANGLE IRON
48 3/8" • 3 3/4" MACHINE BOLTS
16 - 3/8" • 3 1/2" MACHINE BOLTS
20 - 1/2" • 4 1/2" LAG SCREWS
1 1/2" • 8'-8" TIE ROD
2" • 4" HARDWOOD
3" • 12"
STRAP-IRON LOOPS - U-BOLTS, OR EYEBOLTS
SHAFT MAY BE 2" PIPE OR 1 1/4" SOLID SHAFT
11 1/2"
7 1/2"
1 1/2"
6" STEEL CUTTING BLADE
SECTION CUTTING BLADE
STRAP-IRON HITCH & BRACE
ANGLE IRON CORNERS
1 1/2" LOG CHAIN
8" CLEARANCE BETWEEN CROSS PC. & ROLLER
2" • 12" SCRAPER
18" ROLLER SAME AS REAR
WASHER ROLLER SEPARATOR
2" • 6"
2" • 8"
2'-8"
NOTE: EXACT TYPE OF BEARING MAY VARY - DEPENDING ON WHAT BUILDER MAY HAVE ON HAND - IMPLEMENT WHEEL & BEARING RECOMMENDED
TO CONTROL FROM TRACTOR USE TRACTOR IMPLEMENT LEVER ASSEMBLY, OR ATTACH A PULLEY TO REAR CROSS MEMBER AND USE 1/2" ROPE OR 3/16" CABLE
2" • 4" HARDWOOD LEVER
IRON ROD
3" • 12"
2" • 6"
8'-6"
2" • 6"
2" • 8"
ANGLE IRON CORNERS
2" • 12" SCRAPER
8" CLEARANCE TO ROLLER
2'-6"
27'-0"
3" • 12"
1/2" TIE ROD
9'-0"
1'-10"
3/8"
18" ROLLERS CORRUGATED IRON-PIPE - OLD RANGE BOILERS - LOGS, OR BUILT UP WOOD
8'-0" (VARY TO FIT ROLLER)
IRRIGATION LEVELER FLOAT
2 pcs 2" • 12" HARDWOOD CROSSED & BOLTED WITH 4 - 3/8" BOLTS
AXLE
NAILS THRU PIPE OR RANGE BOILERS
ELEV. BUILT UP WHEEL END FOR METAL ROLLERS
ALTERNATE ROLLER OF WOOD
1'-6"
13 - 2" • 4"S 3'-10 1/2" LONG
BLOCKS FROM 2" • 8"S
THRUST WASHERS
1 1/4" CR SHAFT 8'-8" LONG
DOUBLE THRUST WASHER
3'-10 1/2"
3'-10 1/2"
NOTE:- ROLLER CAN BE BUILT AS SHOWN OR CAN BE BUILT OF LOG WITH AUTO AXLES DRIVEN IN ENDS, OR TWO RANGE BOILERS END TO END FOR EACH ROLLER

Figure 24.



SIDE ELEVATION
SCALE ¾"=1'0"

P L A N
SCALE ¾"=1'0"

IRRIGATION DITCHER

BILL OF MATERIAL FOR IRRIGATION DITCHER

WOOD

Ⓐ 2 - 3" × 12" × 6'0" BRIDGE PLANK - (SIDES)
Ⓑ 1 - 4" × 6" × 8'0" HICKORY OR OAK - (TONGUE)
Ⓒ 2 - 2" × 12" × 2'6" PINE SPREADERS
Ⓓ 1 - 4" × 4" × 6'0" HICKORY OR OAK - (SKID)

IRON

Ⓔ 2 - ½" × 1½" × 3'0" STRAP IRON (HEIGHT ADJUSTERS)
Ⓕ 1 - ½" × 2" × 3'4" STRAP IRON (SKID SUPPORT)
Ⓖ 2 - ½" × 1½" × 2'0" STRAP IRON (HANDLES)
Ⓗ 2 - ½" × 1½" × 1'9" STRAP IRON (HEIGHT ADJUSTER CHECKS)
Ⓙ 2 - 1½" × 1½" × 6'0" ANGLE IRON (SIDE SHOES)
Ⓚ 4 - 1½" × 1½" × 1'0" ANGLE IRON (SPREADER SUPPORTS)
Ⓛ 1 - ½" × 2½" × 1'8" STRAP IRON
Ⓜ 1 - ½" × 2½" × 2'6" STRAP IRON (CLEVIS)
Ⓝ 2 - ⅜" × 4" DIAM RINGS (CLEVIS)
Ⓞ 1 - ⅜" × 5" × 6½" FLAT PLATE
Ⓟ 1 - ½" × 2" × 1'8" STRAP IRON (SKID CLEVIS)
Ⓠ 1 - ⅜" × 4" × 5'6" STRAP IRON (SKID SHOE)
Ⓡ 2 - 12" × 6'0" #16 GAGE GALV IRON (SIDE PROTECTION)
1 - 12" × 2'0" #16-GAGE REINFORCING TIP

BOLTS

Ⓢ 1 - ¾" × 24"
2 - 5/16" × 1½" "U" PIECE ELEVATOR Ⓔ
2 - 5/16" × 7" TONGUE CLEVIS Ⓜ TO Ⓑ
2 - ⅜" × 7" TONGUE SKID Ⓛ TO Ⓑ
2 - ⅜" × 9¾" TONGUE TO CROSSBOARDS Ⓒ
4 5/16" × 3" ELEVATOR GUIDES Ⓔ TO CROSSBOARDS Ⓒ
8 - ¼" × 2¼" ANGLE IRON Ⓚ TO CROSSBOARDS Ⓒ
10 ¼" × 3¾" 8 FROM ANGLE IRON Ⓚ TO BEAM Ⓐ
2 FOR TOP BOLTS IN HANDLES
4 - ⅜" × 4½" - BOTTOM SKID Ⓠ TO BEAM Ⓓ
6 - ⅜" × 3½" ANGLE IRON Ⓙ TO BEAM Ⓐ
2 ⅜" × 1" TRIANGULAR PLATE Ⓞ TO ANGLE IRON Ⓙ
4 ⅜" × 4" - FRONT "U" IRON Ⓕ TO BEAM Ⓐ
1 ⅜" × 6" FRONT "U" IRON Ⓕ TO TONGUE Ⓑ
2 - ⅜" × 12" - COLLAR TIE FOR BEAMS Ⓐ
1 - ⅜" × 5" - "U" PIECE ELEVATOR Ⓔ TO SKID Ⓓ
2 ⅜" × 2" LAG SCREWS FOR HANDLES

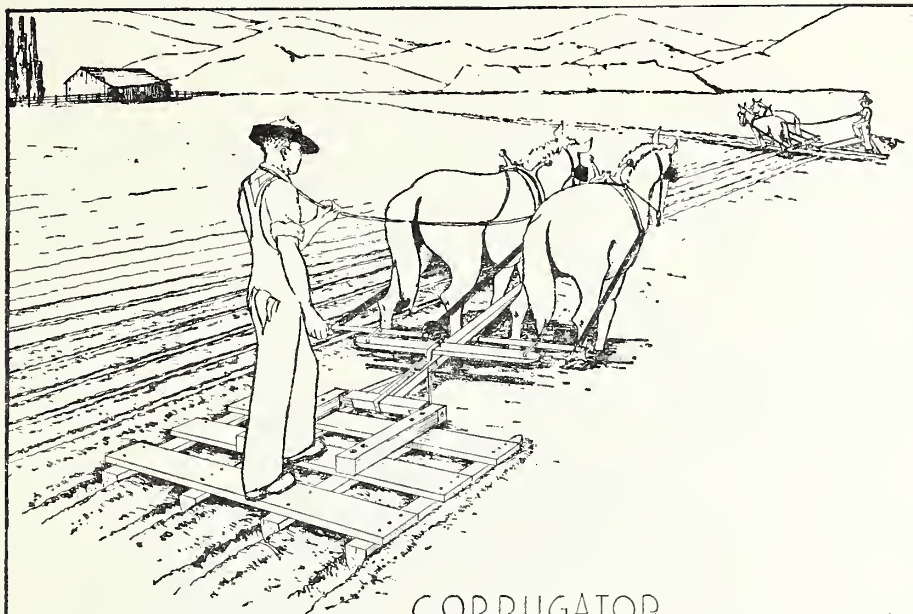
WASHERS

16 FOR ¼" BOLTS
4 FOR 5/16" BOLTS
18 FOR ⅜" BOLTS

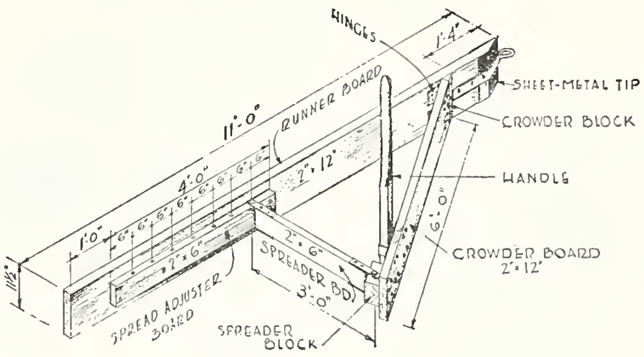
NAILS

APPROXIMATELY 100 8-PENNY WIRE
6 LARGE SPIKES

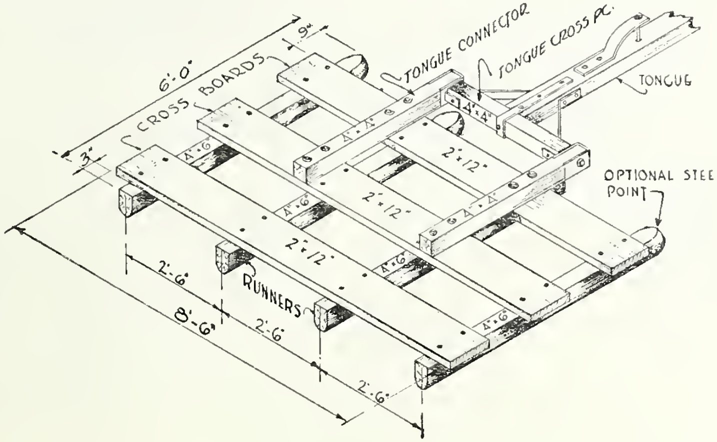
Figure 25.



ADJUSTABLE CROWDER



CORRUGATOR



MATERIAL LISTS

ADJUSTABLE CROWDER

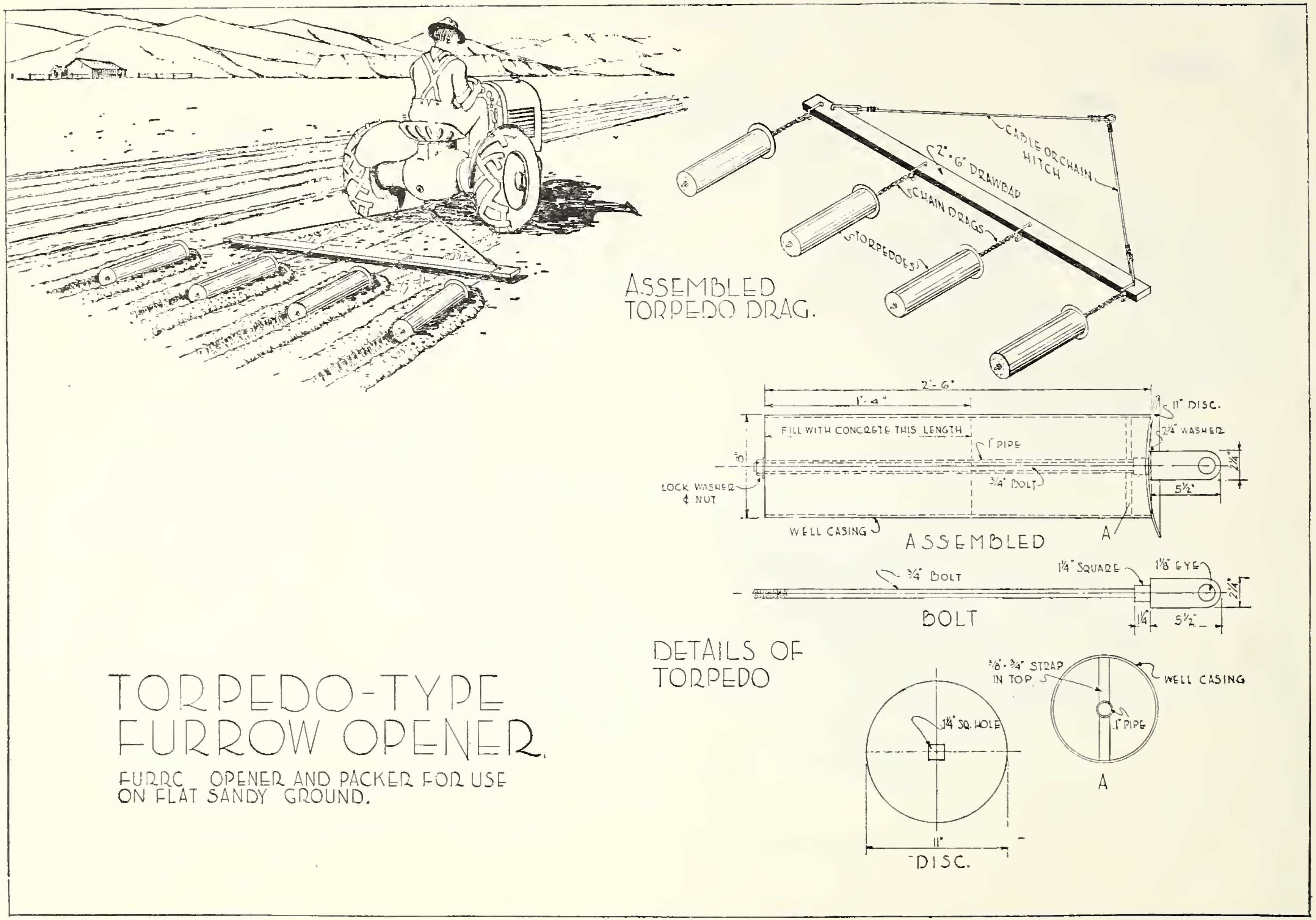
1 PC. 2"×12"×11'-0" RUNNER BOARD
1 PC 2"×12"× 6'-0" CROWDER BOARD
1 PC. 2"× 6"× 3' 0" SPREADER BOARD
1 PC 2"× 6"× 4'-0" SPREAD ADJUSTER BOARD.
1 PC 1½"× 2½"× 4' 6" HARDWOOD HANDLE
1 PC 4"×6"×6" - SPREADER BLOCK
1 PC. ⅜"×2"×36" STRAP IRON WITH ¾" RND-2½" DIA. HITCH RING
2 PCS ⅜"×2"×10" HANDLE SUPPORTS
4 PCS ⅜"×1¾"×8" SPREADER-BOARD ENDS
1 PC. 12"×12" HEAVY SHEET-METAL CUTTING POINT.
3- ⅜"×3" BOLTS-HITCH RING TO RUNNER BD.
3- ¼"×4" BOLTS CROWDER BLK. TO RUNNER BD.
16- ¼"×2½" BUTTON-HEAD BOLTS FOR HINGES
8- ¼"×2½" BOLTS FOR HANDLE SUPPORTS
4- ⅜"×7" " " SPREADER BLOCK
2- ½"×7" " " " BOARD BEARINGS
4- ⅜"×7" " " " " TIPS.
6- ½"×5" " " SPREADER ADJ. BD TO RUNNER.
2-PCS. 3" SURFACE HINGES

CORRUGATOR

4 PCS.- 4"×6"×6'0" FOR RUNNERS
3 PCS.- 2"×12"×8'-6" FOR CROSS BOARDS
2 PCS. 4"×4"×4'-0" FOR TONGUE CONNECTOR
1 PC. 4"×4"×2'-10" FOR TONGUE CROSS PC.
1 PC. OLD WAGON TONGUE
1 PC. ¼"×2½"×12" STRAP IRON CLEVIS.
1 PC. ¼"×1½"×3'-0" " " TONGUE TO CROSS PC.
2 PCS. ¼"×2"×3'-0" " " TONGUE BRACES
2 PCS. ¼"×4"×1'-4" " " TONGUE CONNECTOR ENDS
1- ¾"×8" BOLT - DOUBLETREE TO CLEVIS
2- ⅜"×6" " - CLEVIS TO TONGUE
7- ½"×6" " - TONGUE TO CROSS TIE.
1- ½"×8" LAG SCREW-CROSS TIE TO TONGUE
2- ⅝"×12" " " CONNECTOR TO CROSS-TIE AXLE
8- ⅜"×8" BOLTS WITH WASHERS- TONGUE CONNECTORS TO CROSS BOARDS.
24- 5/16"×8" CGE. BOLTS-H'DS. IN RUNNERS- CROSS BOARDS TO RUNNERS.

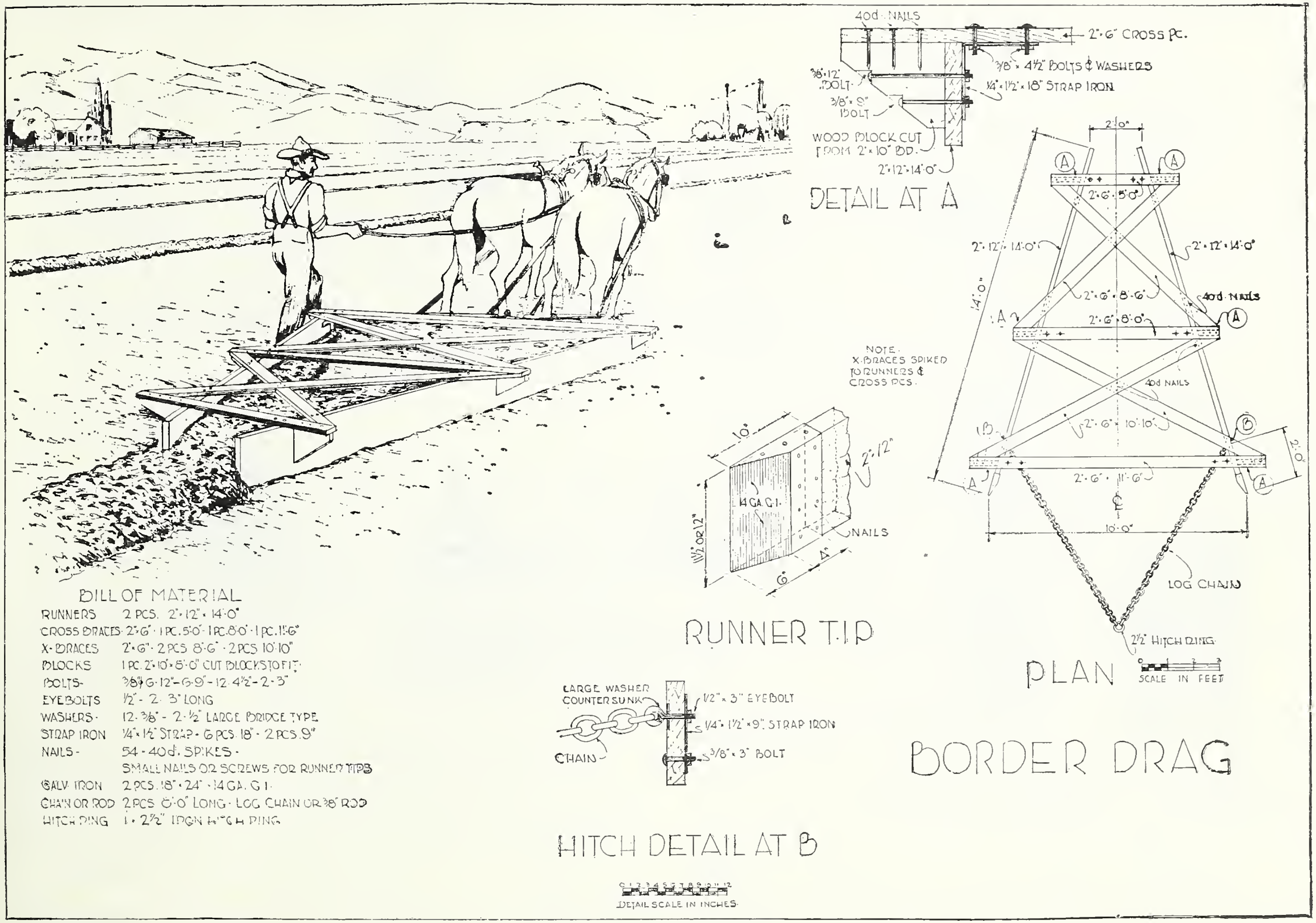
0 3
SCALE IN FEET.

Figure 26.



ASSEMBLED TORPEDO DRAG.
CABLE OR CHAIN HITCH
2"×6" DRAWBAR
CHAIN DRAGS
TORPEDOES
2'-6"
1'-4"
11" DISC.
2¼" WASHER
FILL WITH CONCRETE THIS LENGTH
1" PIPE
8"
LOCK WASHER & NUT
¾" BOLT
2¼"
5½"
WELL CASING
ASSEMBLED
A
¾" BOLT
1¼" SQUARE
1⅛" EYE
2¼"
BOLT
1¼
5½"
DETAILS OF TORPEDO
⅜×¾" STRAP IN TOP
WELL CASING
1¼" SQ. HOLE
1" PIPE
11"
DISC.
A
TORPEDO-TYPE FURROW OPENER.
FURROW OPENER AND PACKER FOR USE ON FLAT SANDY GROUND.

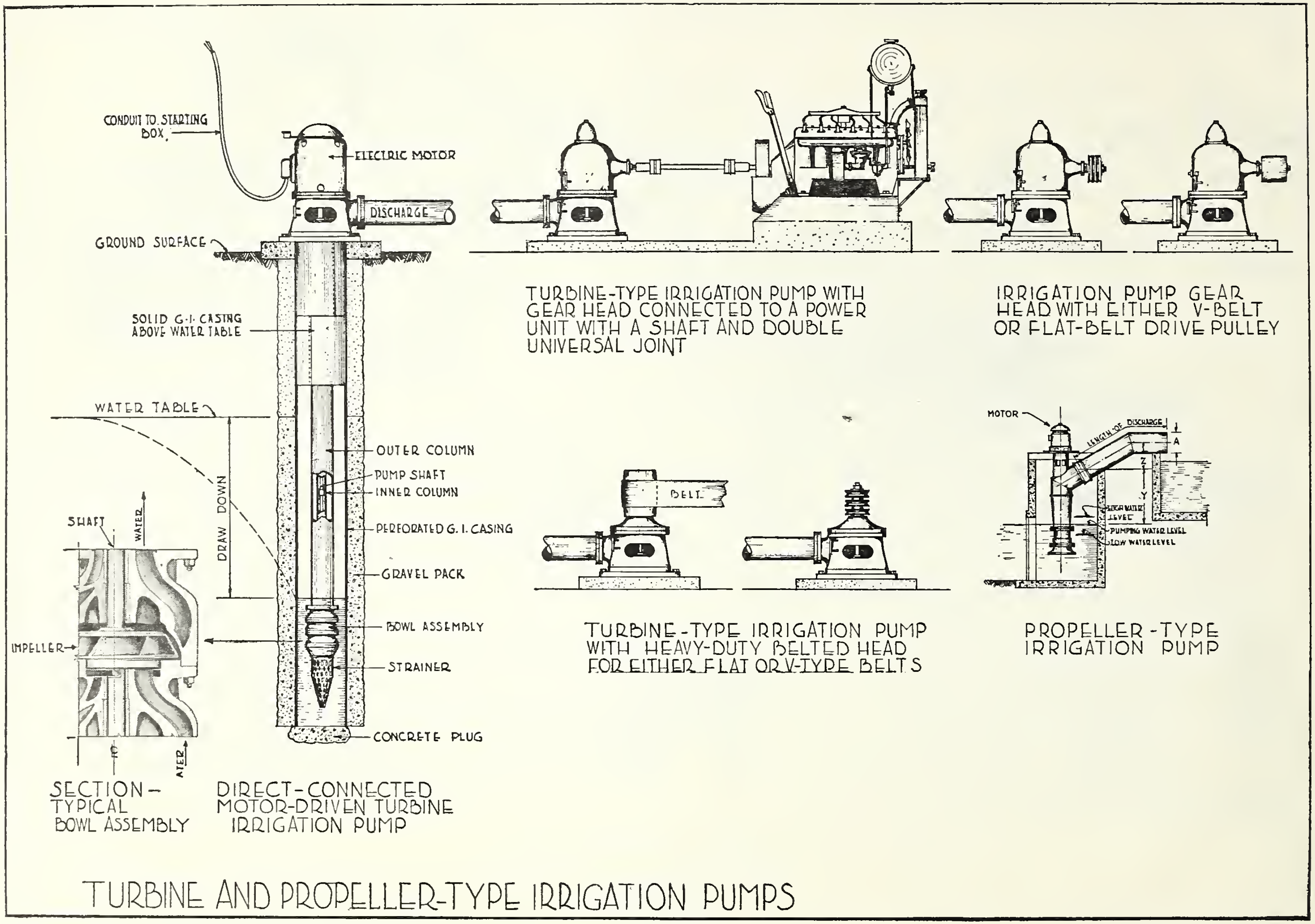
Figure 27.



BILL OF MATERIAL

RUNNERS	2 PCS. 2"×12"×14'-0"
CROSS BRACES	2"×6" - 1 PC. 5'-0" - 1 PC. 8'-0" - 1 PC. 11'-6"
X-BRACES	2"×6" - 2 PCS 8'-6" - 2 PCS 10'-10"
BLOCKS	1 PC. 2"×10"×8'-0" CUT BLOCKS TO FIT.
BOLTS-	3/8" - 6-12" - 6-9" - 12-4½" - 2-3"
EYEBOLTS	1/2" - 2 - 3" LONG
WASHERS-	12-3/8" - 2-½" LARGE BRIDGE TYPE
STRAP IRON	1/4"×1½" STRAP - 6 PCS. 18" - 2 PCS. 9"
NAILS-	54 - 40d. SPIKES - SMALL NAILS OR SCREWS FOR RUNNER TIPS
GALV. IRON	2 PCS. 18"×24" - 14 GA. G.I.
CHAIN OR ROD	2 PCS. 6'-0" LONG - LOG CHAIN OR 3/8" ROD
HITCH RING	1 - 2½" IRON HITCH RING

Figure 28.



TURBINE-TYPE IRRIGATION PUMP WITH GEAR HEAD CONNECTED TO A POWER UNIT WITH A SHAFT AND DOUBLE UNIVERSAL JOINT

IRRIGATION PUMP GEAR HEAD WITH EITHER V-BELT OR FLAT-BELT DRIVE PULLEY

TURBINE-TYPE IRRIGATION PUMP WITH HEAVY-DUTY BELTED HEAD FOR EITHER FLAT OR V-TYPE BELTS

PROPELLER-TYPE IRRIGATION PUMP

SECTION—TYPICAL BOWL ASSEMBLY

DIRECT-CONNECTED MOTOR-DRIVEN TURBINE IRRIGATION PUMP

TURBINE AND PROPELLER-TYPE IRRIGATION PUMPS

FIGURE 29.

The size of the suction and discharge pipe must be adapted to the quantity of water to be pumped. The table shown in figure 30 indicates the lost head due to friction per 100 feet of pipe length, as well as the losses through pipe fittings in terms of equivalent length of pipe.

An example—see sketch in upper left corner figure 30:

Let $A+B=20$ feet actual head.
Let $C+E=200$ feet actual length of 8-inch discharge and suction pipe.
D=Medium-sweep elbow, equivalent to 13.6 feet of 8-inch pipe.
F=Standard elbow, equivalent to 21.7 feet of 8-inch pipe.
Compute total head when pump is delivering 1,000 gallons per minute.
An 8-inch pipe has 3.02 feet of friction head for 100 feet of pipe length when carrying 1,000 gallons per minute. The total head is calculated on the basis of total length of pipe plus the equivalent length for fittings. In the example it is 200+13.6+21.7 or 235.3 feet of 8-inch pipe. Since the friction head is given per 100 feet of pipe it is necessary to divide 235.3 by 100, giving 2.353. This, multiplied by 3.02, gives 7.05, the friction head for 235.3 feet of 8-inch pipe. The total head is then 7.05 friction head plus 20 feet actual head or 27.05 feet.
There is a slight additional loss due to the foot-valve resistance and other factors.
The friction-loss table is based on commonly used pipe.

PUMPING FROM A STREAM OR POND

Water for garden irrigation can be pumped from ponds and streams if the lift is not too great. A small horizontal centrifugal pump set not higher than 10 feet above the water and powered by a gasoline engine is the equipment ordinarily used. Pumps of the type may be had in sizes which will deliver from 30 to 1,000 gallons or more per minute. See figure 31 for illustration of pumping system for streams or ponds.

PUMPING FROM SHALLOW IRRIGATION WELLS

Along river bottoms where the ground water level is always within 10 feet or less of the surface, small irrigation wells may be successfully used for the irrigation of farm gardens. Casings for such wells are ordinarily made from sheet metal slotted to permit water to enter. In some instances old range boilers with the ends cut out are welded together and slotted with a welding torch. Small centrifugal pumps set at ground surface are quite satisfactory. A diagrammatic section of a shallow-well pump is shown in figure 31.

A POWER-REQUIREMENT CHART FOR PUMPING

By means of the chart shown in figure 32 it is possible to determine power requirements, fuel consumption, and electrical energy costs at various pumping-plant efficiencies and at various lifts.

At *A* at the upper left is the scale of lifts from 0 to 80 feet. The lift must include not only static head but friction and velocity heads as well.

At *B*, upper center, over-all plant efficiencies are represented. Over-all efficiencies in small, irrigation pumping plants run from 40 to 60 percent.

On the line *XX* is shown horsepower values when pumping 1,000 gallons per minute.

In the center of the chart, at *C*, the fuel consumption of various types of engines is represented.

The approximate number of horsepower-hours developed per gallon of fuel for various types of engines is given below:

Type of engine:	*Horsepower-hours per gallon of fuel*
Gasoline engines in poor repair	6 to 7
Gasoline engines in good repair	8 to 9.5
Engines using fuel oil, semi-Diesel, etc.	9 to 11
High speed Diesel	11 to 14.5

At the lower part of the chart, at *E*, is given the power cost in dollars per acre-foot of water pumped at various rates in cents per kilowatt-hour.

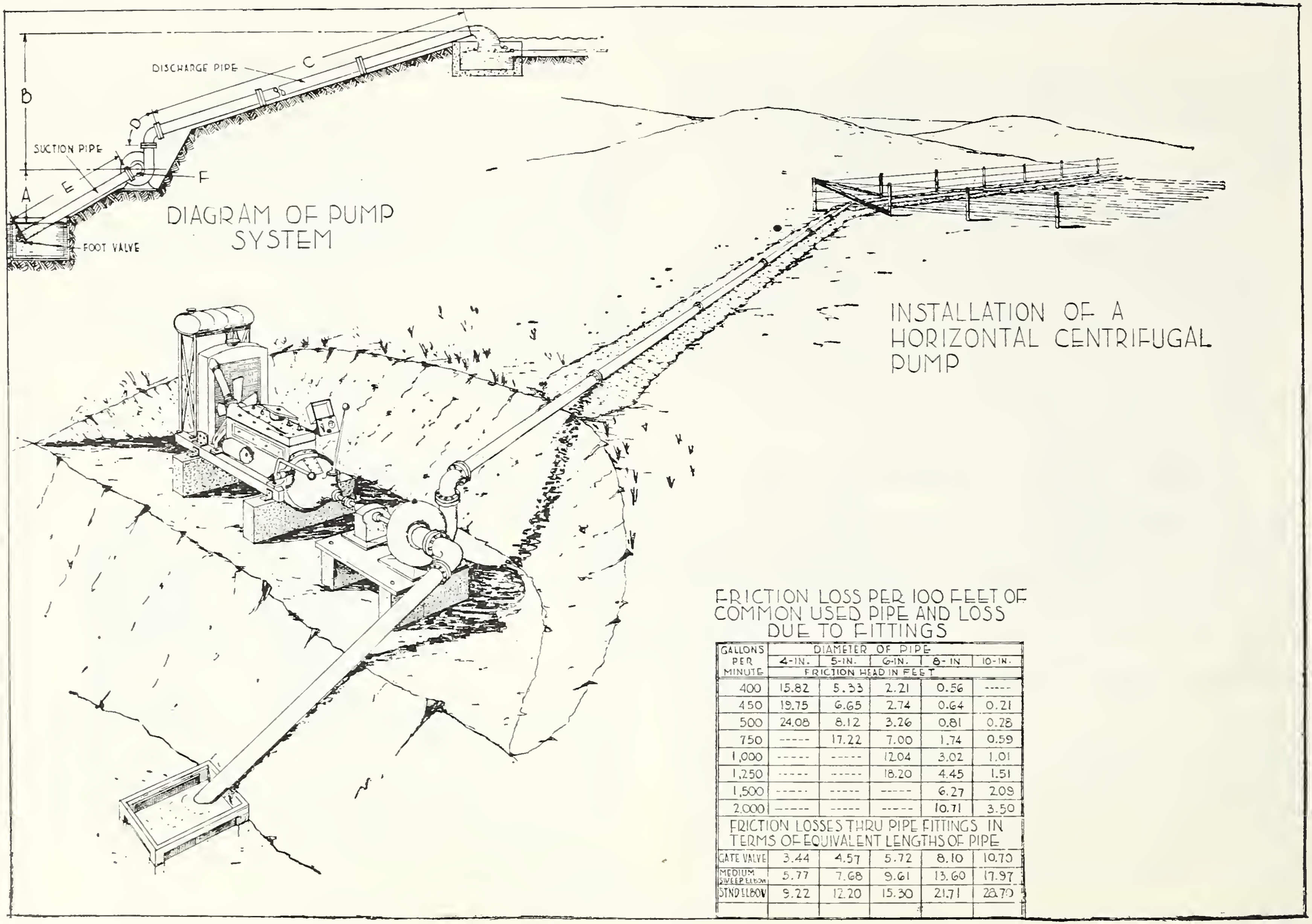
The line *YY* at the bottom of the chart represents the power required in kilowatts, when pumping 1,000 gallons per minute.

USE OF THE CHART

The use of the chart is shown by the following example:

The lift of a given irrigation pump is 45 feet; the over-all efficiency of the plant is estimated at 50 percent. What will be the horsepower required to pump 1,000 gallons per minute? How many gallons of fuel will be required to pump an acre-foot of water, using fuel oil in an engine other than Diesel? What would be the cost in dollars per acre-foot, using electricity at 2 cents per kilowatt-hour?

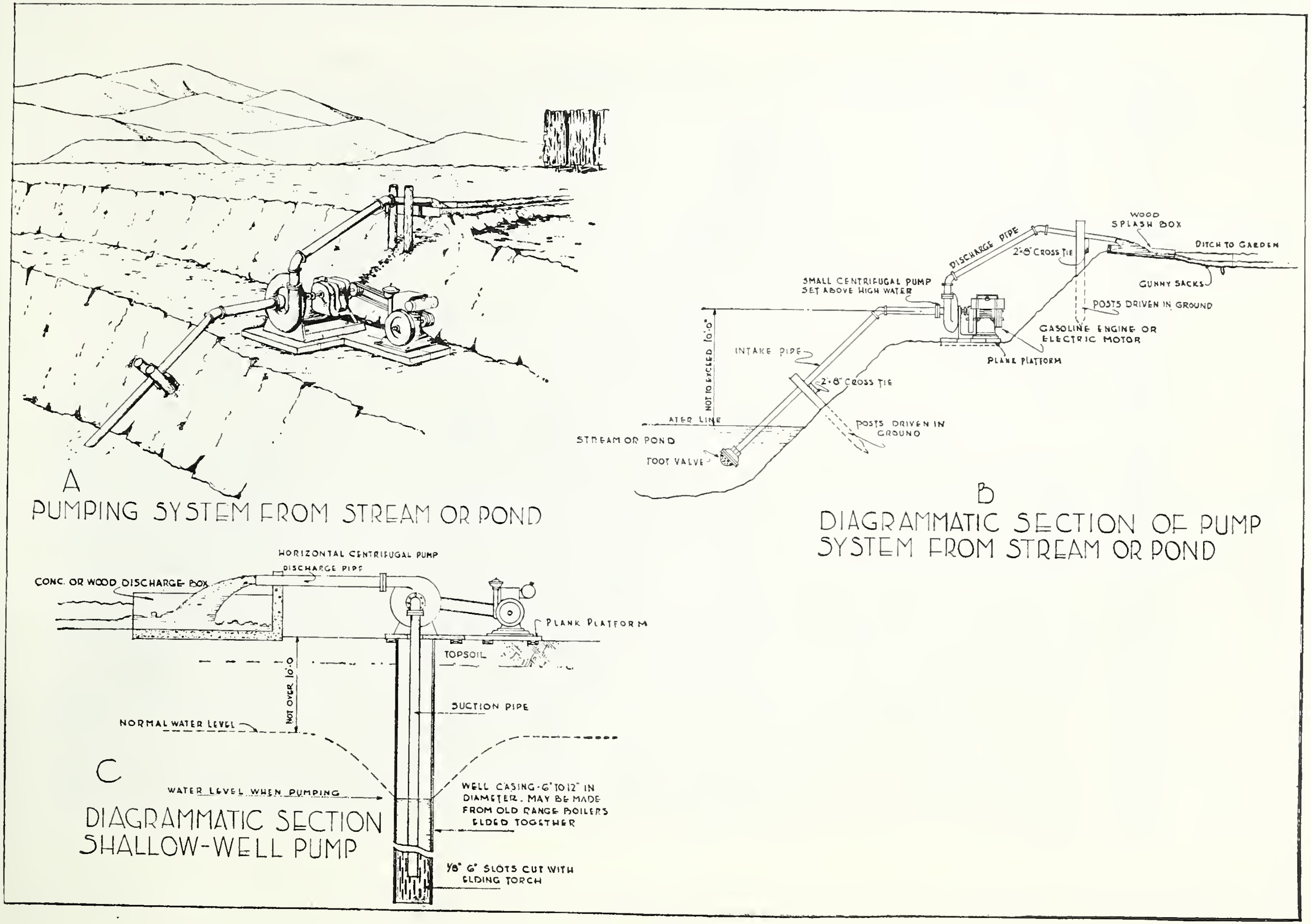
Starting at the upper left-hand margin locate the lift, 45 feet is at point *A*. Follow to the right until the 50-percent efficiency line is intersected at point *B*.



FRICTION LOSS PER 100 FEET OF COMMON USED PIPE AND LOSS DUE TO FITTINGS

GALLONS PER MINUTE	DIAMETER OF PIPE				
	4-IN.	5-IN.	6-IN.	8-IN	10-IN.
	FRICTION HEAD IN FEET				
400	15.82	5.33	2.21	0.56	-----
450	19.75	6.65	2.74	0.64	0.21
500	24.08	8.12	3.26	0.81	0.28
750	-----	17.22	7.00	1.74	0.59
1,000	-----	-----	12.04	3.02	1.01
1,250	-----	-----	18.20	4.45	1.51
1,500	-----	-----	-----	6.27	2.09
2,000	-----	-----	-----	10.71	3.50
FRICTION LOSSES THRU PIPE FITTINGS IN TERMS OF EQUIVALENT LENGTHS OF PIPE					
GATE VALVE	3.44	4.57	5.72	8.10	10.70
MEDIUM SWEEP ELBOW	5.77	7.68	9.61	13.60	17.97
STND ELBOW	9.22	12.20	15.30	21.71	28.70

FIGURE 30.

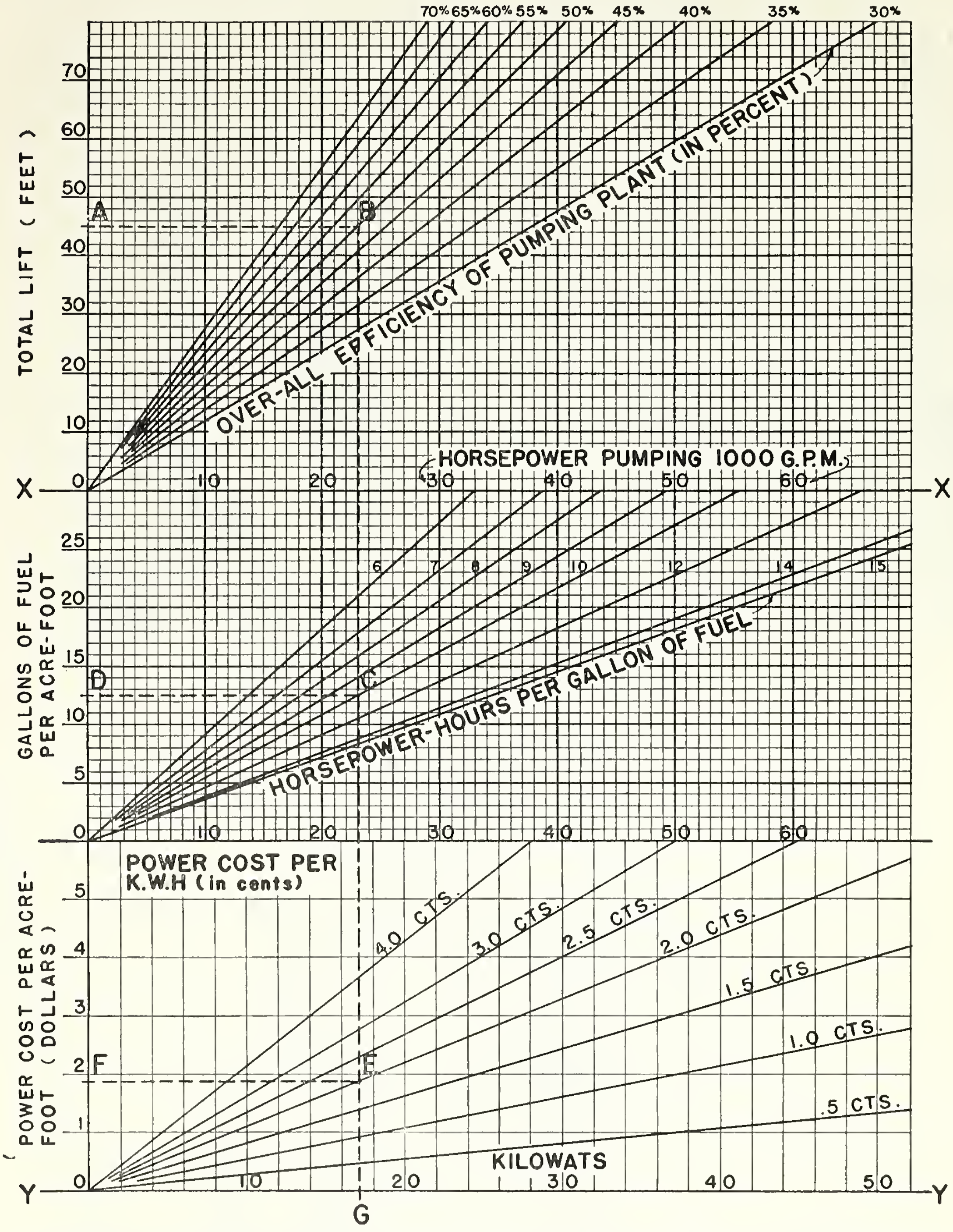


A
PUMPING SYSTEM FROM STREAM OR POND

B
DIAGRAMMATIC SECTION OF PUMP SYSTEM FROM STREAM OR POND

C
DIAGRAMMATIC SECTION SHALLOW-WELL PUMP

FIGURE 31.



POWER REQUIREMENTS - FUEL CONSUMPTION AND ELECTRICAL ENERGY COSTS AT VARIOUS PUMPING PLANT EFFICIENCIES.

FIGURE 32.

From point *B* follow downward until the line *XX* is intersected. It will be noted that 23 horsepower is required to pump 1,000 gallons per minute. Continue downward until the line representing 10 horsepower-hours per gallon is intersected at *C*. From the point *C* follow to the left to the point *D*, which shows that 12.5 gallons of fuel will be required to pump an acre-foot of water.

If the cost in dollars per acre-foot is required, with electrical energy costing 2 cents per kilowatt-hour, follow downward from point *C* to point *E* on the diagonal line showing 2 cents cost. From point *E* follow to the left to point *F*, which shows the cost of pumping 1 acre-foot of water under the given conditions to be $1.90.

If the electrical load is required, follow downward from *E* to Point *G*, which shows a value of 17+.

If lifts other than those shown are to be used, certain allowances must be made. If values for a 100-foot lift are desired, those given for a 50-foot lift may be doubled, etc.

PUMP HOUSE

Figure 33 shows dimensioned drawing of a small pump house and division box. For larger equipment the pump house would have to be expanded accordingly.

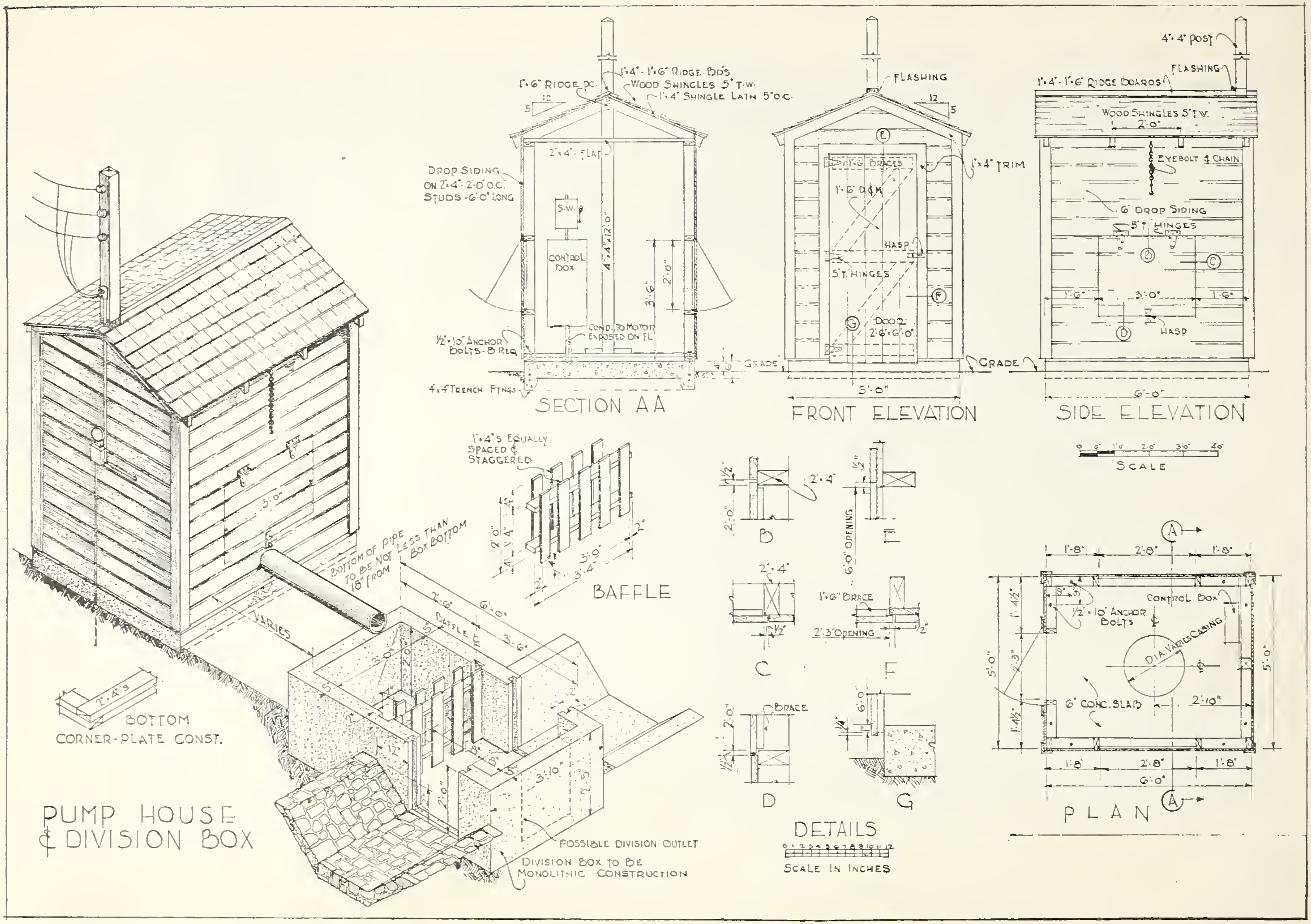

PUMP HOUSE
& DIVISION BOX
BOTTOM
CORNER-PLATE CONST.
2"·4"s
VARIES
3'-0"
BOTTOM OF PIPE TO BE NOT LESS THAN 18" FROM BOX BOTTOM
2'-6"
6'-0"
BAFFLE ℄
3'-6"
3'-0"
12"
8"
3'-10"
2'-5"
2'-0"
POSSIBLE DIVISION OUTLET
DIVISION BOX TO BE MONOLITHIC CONSTRUCTION
SECTION AA
1"·6" RIDGE PC.
1"·4"-1"·6" RIDGE BD'S
WOOD SHINGLES 5" T.W.
1"·4" SHINGLE LATH 5" O.C.
DROP SIDING ON 2"·4"-2'-0" O.C. STUDS-6'-0" LONG
2"·4"-FLAT
S.W.
CONTROL BOX
4"·4"-12'-0"
3'-6"
2'-0"
COND. TO MOTOR EXPOSED ON FL.
½"·10" ANCHOR BOLTS-8 REQ.
4x4 TRENCH FTNGS.
GRADE
FRONT ELEVATION
FLASHING
1"·4" TRIM
1"·6" BRACES
1"·6" D.&M.
HASP
5" T. HINGES
DOOR 2'-6"·6'-0"
5'-0"
SIDE ELEVATION
4"·4" POST
FLASHING
1"·4"-1"·6" RIDGE BOARDS
WOOD SHINGLES 5" T.W.
2'-0"
EYEBOLT & CHAIN
6" DROP SIDING
5" T. HINGES
1'-6"
3'-0"
HASP
6'-0"
SCALE
BAFFLE
1"·4"s EQUALLY SPACED & STAGGERED
2'-0"
3'-0"
3'-4"
2"
DETAILS
B
2"·4"
2'-0"
E
6'-0" OPENING
C
2"·4"
F
1"·6" BRACE
2'-3" OPENING
D
BRACE
2'-0"
G
6'-0"
SCALE IN INCHES
PLAN
1'-8"
2'-8"
1'-8"
CONTROL BOX
½"·10" ANCHOR BOLTS
DIA. VARIES CASING
6" CONC. SLAB
2'-10"
5'-0"
1'-4½"
2'-3"
6'-0"

FIGURE 33.